



10,207/B

NIX-K





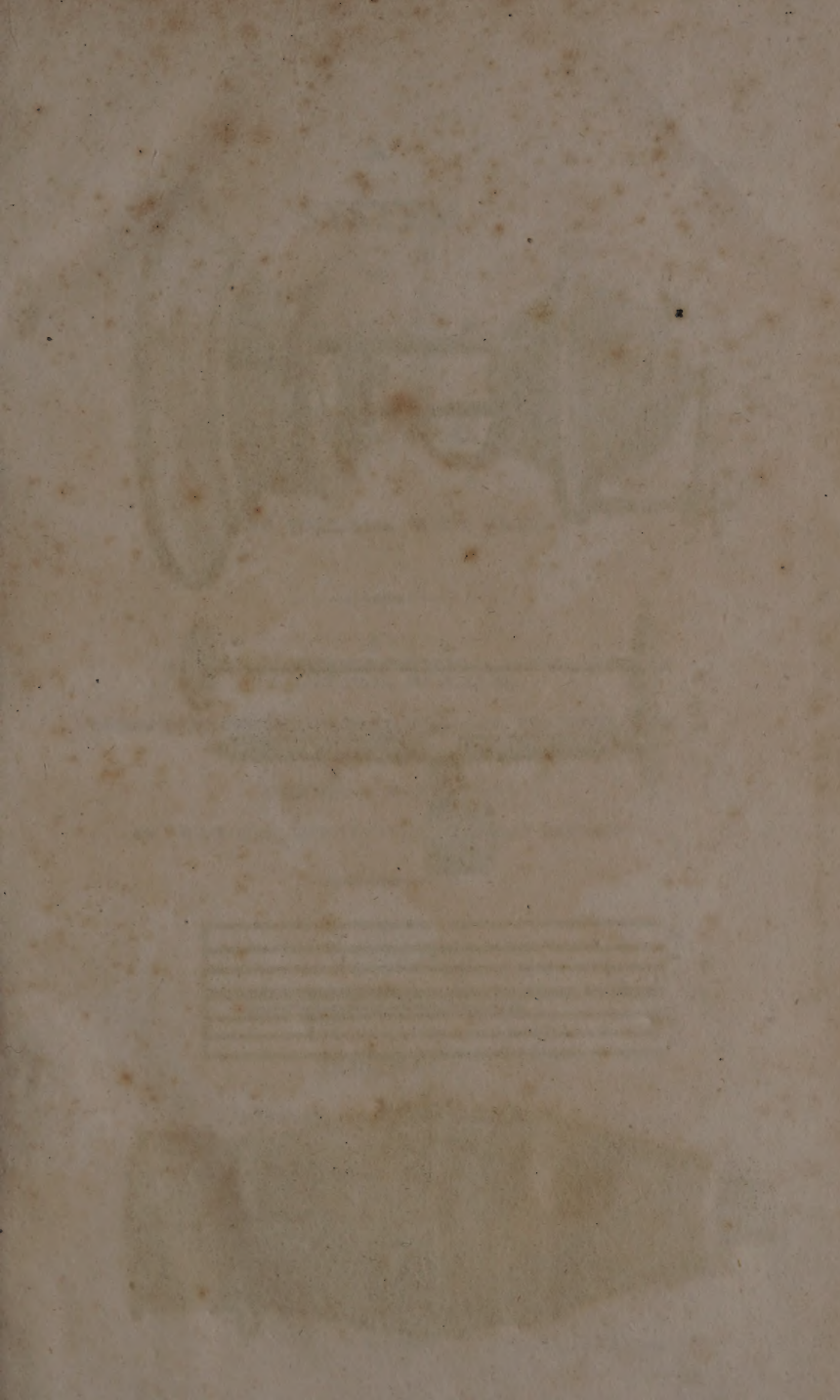


Fig. 1.

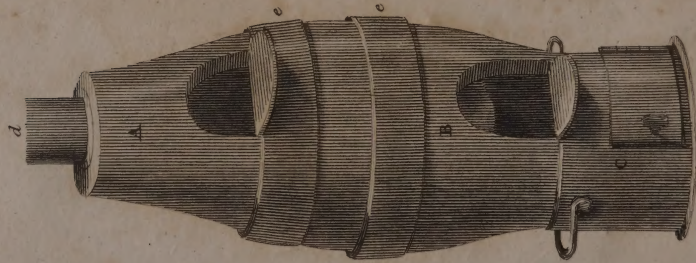


Fig. 3.

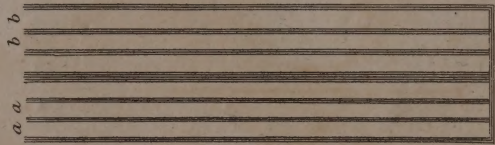


Fig. 4.

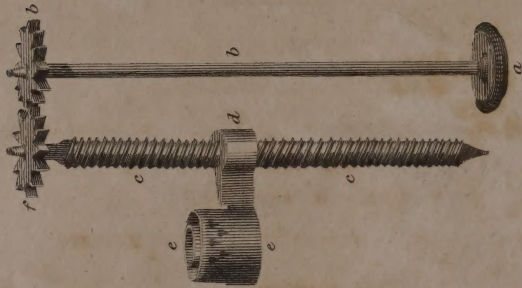
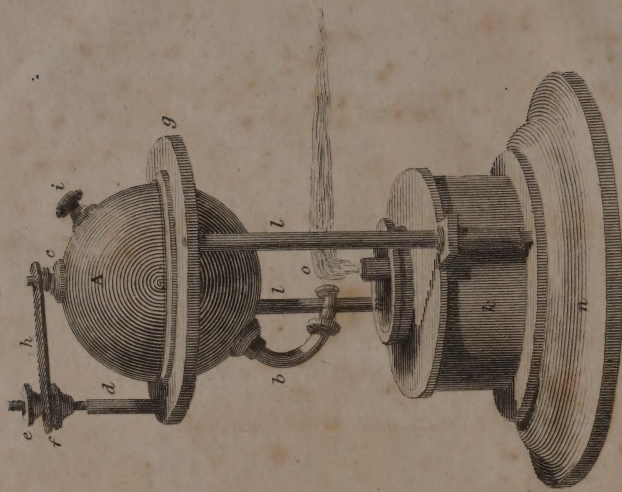


Fig. 2.



A
SYSTEM
OF
THEORETICAL AND PRACTICAL
CHEMISTRY.

IN TWO VOLUMES, WITH PLATES.

BY
FREDRICK ACCUM,
TEACHER OF PRACTICAL CHEMISTRY, PHARMACY, AND MINERALOGY:
AND
CHEMICAL OPERATOR
IN THE ROYAL INSTITUTION OF GREAT BRITAIN.

VOLUME II.

LONDON:

PRINTED FOR THE AUTHOR,
Old Compton Street, Soho;
AND G. KEARSLEY, FLEET STREET; BELL AND BRADFUTE,
EDINBURGH; BRASH AND REID, GLASGOW; AND
ARCHER AND COLBERT, DUBLIN.

A few Copies of this Work are printed on Paper made of Straw only.

1803.

A
SYSTEM
OF
THEORETICAL AND PRACTICAL
CHEMISTRY.

IN TWO VOLUMES, WITH PLATES.



BY
FREDRICK ACCO

LECTURER OF PRACTICAL CHEMISTRY, PHARMACY, AND MINERALOGY

AND

CHEMICAL OPERATOR.

IN THE ROYAL INSTITUTION OF GREAT BRITAIN.

VOLUME II.

LONDON:

PRINTED FOR THE AUTHOR,

By J. H. COOKE, 10, BLOOMSBURY PLACE.

AND C. KENNEDY, 15, PATERNOSTER ROW, LONDON, AND
J. H. COOKE, 10, BLOOMSBURY PLACE, LONDON.
LONDON AND BIRMINGHAM: J. H. COOKE, 10, BLOOMSBURY PLACE.

From the Press of G. HAYDEN,
Russell Court, Covent Garden.

1803.

CONTENTS

OF

THE SECOND VOLUME.

PART XXXIII.

METALS.

	Page
E NUMERATION of metals.....	2
Classification of metals	
Natural history of metals.....	3
General physical properties of metals.....	4

PART XXXIV.

ARSENIC.

SECT. I....Natural history of arsenic.....	6
Properties of arsenic.....	7
Method of obtaining arsenic.....	8
SECT. II....Experimental proofs of the properties of arsenic	9
Experiment I. II.....	
III. IV. V.....	10
VI. VII.....	11
Analysis of ores of arsenic.....	

PART XXXV.

TUNGSTEN.

	Page.
Natural history of tungsten.....	13
Properties of tungsten.....	14
Methods of obtaining tungsten.....	
Analysis of ores of tungsten.....	16

PART XXXVI.

MOLYBDENA.

Natural history of molybdena.....	17
Properties of molybdena.....	18
Methods of obtaining molybdena.....	
Analysis of ores of molybdena.....	19

PART XXXVII.

CHROME.

Natural history of chrome.....	20
Properties of chrome.....	
Methods of obtaining chrome.....	21
Analysis of ores of chrome.....	22

PART XXXVIII.

COLUMBIUM.

Natural history of columbium.....	23
Analysis of the ore of columbium.....	24

PART XXXIX.

TITANIUM.

	Page
Natural history of titanium.....	26
Properties of titanium.....	27
Methods of obtaining titanium.....	
Analysis of ores of titanium.....	28

PART XL.

URANIUM.

Natural history of uranium.....	29
Properties of uranium.....	
Methods of obtaining uranium.....	30
Analysis of ores of uranium.....	31

PART XLI.

COBALT.

SECT. I....Natural history of cobalt.....	32
Properties of cobalt.....	33
Method of obtaining cobalt.....	34
SECT. II...Experimental proofs of the properties of cobalt	35
Experiment I. II.	
III. IV.....	36
Analysis of ores of cobalt.....	38

PART XLII.

NICKEL.

	Page
Natural history of nickel.....	39
Properties of nickel.....	40
Method of obtaining nickel.....	41
Analysis of ores of nickel.....	42

PART XLIII.

MANGANESE.

SECT. I...Natural history of manganese.....	44
Properties of manganese.....	45
Methods of obtaining manganese.....	
SECT. II...Experimental proofs of the properties of man- ganese.....	47
Experiment I. II.	
III. IV.	48
V.	49
Analysis of ores of manganese.....	50

PART XLIV.

BISMUTH.

SECT. I....Natural history of bismuth	51
Properties of bismuth.....	52
Method of obtaining bismuth.....	52
SECT. II...Experimental proofs of the properties of bis- muth	53
Experiment I. II.	
III. IV.	54
Analysis of ores of bismuth.....	55

PART XLV.

ANTIMONY.

	Page
SECT. I...Natural history of antimony	56
Properties of antimony.....	57
Methods of obtaining antimony.....	
SECT. II...Experimental proofs of the properties of anti- mony.....	59
Experiment I.....	
II.....	60
III.....	61
IV. V.....	62
VI.....	64
VII.....	65
VIII.....	67
Analysis of ores of antimony.....	

PART XLVI.

TELLURIUM.

Natural history of tellurium.....	68
Properties of tellurium.....	69
Methods of obtaining tellurium.....	
Analysis of ores of tellurium.....	70

PART XLVII.

MERCURY.

SECT. I...Natural history of mercury.....	71
Properties of mercury.....	72
Method of obtaining mercury	73
SECT. II...Experimental proofs of the properties of mer- cury.....	74

	Page
Experiment I. II.....	74
III. IV.....	75
V.....	76
VI.....	77
VII. VIII. IX.....	78
X.....	79
XI. XII. XIII.....	80
XIV.....	81
XV.....	82
Analysis of ores of mercury.....	85

PART XLVIII.

ZINC.

SECT. I....Natural history of zinc.....	86
Properties of zinc.....	87
Method of obtaining zinc	88
SECT. II....Experimental proofs of the properties of zinc..	89
Experiment I.....	
II. III.....	90
IV. V. VI.....	91
Analysis of ores of zinc.....	92

PART XLIX.

TIN.

SECT. I....Natural history of tin.....	94
Properties of tin.....	95
Method of obtaining tin	96
SECT. II....Experimental proofs of the properties of tin...	97
Experiment I.....	
II.....	98
III.....	99

CONTENTS OF THE SECOND VOLUME.

vii

	Page
Experiment IV. V. VI.	100
VII. VIII. IX.	101
X. XI.	102
XII. XIII. XIV.	103
XV.	104
XVI. XVII.	105
Analysis of ores of tin,	106

PART L.

LEAD.

SECT. I.....Natural history of lead	107
Properties of lead	108
Method of obtaining lead	109
SECT. II....Experimental proofs of the properties of lead	110
Experiment I.	
II. III.	111
IV. V. VI.	112
VII.	113
Analysis of ores of lead,	114

PART LI.

IRON.

SECT. I.....Natural history of iron.	116
Properties of iron	117
Method of obtaining iron	118
Properties of steel	120
Methods of converting iron into steel	121
Methods of distinguishing iron from steel ...	123
Inferences	

	Page
SECT. II...Experimental proofs of the properties of iron	125
Experiment I. II.....	
III. IV.	126
V.....	127
Analysis of ores of iron.....	131

PART LII.

COPPER.

SECT. I...Natural history of copper.....	132
Properties of copper	134
Methods of obtaining copper	135
SECT. II...Experimental proofs of the properties of copper	136
Experiment I. II.....	
III.	137
IV. V.....	138
VI. VII.....	139
VIII.....	140
Analysis of ores of copper.....	141

PART LIII.

SILVER.

SECT. I.....Natural history of silver.....	143
Properties of silver.....	144
Methods of obtaining silver	145
SECT. II...Experimental proofs of the properties of silver	146
Experiment I. II.	
III. IV.	147
V. VI.....	148
VII. VIII.	149
IX.	150
X.	151
XI.	152

	Page
Silvering	153
Plating	154
Analysis of ores of silver	155
Method of separating silver from copper	158

PART LIV.

GOLD.

SECT. I....Natural history of gold.....	159
Properties of gold	160
Method of obtaining gold	161
SECT. II...Experimental proofs of the properties of gold..	164
Experiment I.....	
II. III.....	165
IV. V.....	166
VI.....	167
VII.....	168
VIII. IX. X.....	169
XI.....	170
Gilding	
Analysis of ores of gold	174
Parting.....	175
Cupellation.....	

PART LV.

PLATINA.

SECT. I....Natural history of platina.....	177
Properties of platina	178
Method of obtaining platina.....	179
SECT. II...Experimental proofs of the properties of platina	181
Experiment I.....	

Experiment II. III. IV.....	Page 182
V.	183

PART LVI.

TANTALITE.

Natural history of tantalite	184
Properties of tantalite.....	185

PART LVII.

EARTHS.

Enumeration of earths.....	186
General physical properties of earth.....	187

PART LVIII.

SILEX.

SECT. I....Natural history of silex	188
Properties of silex.....	189
Methods of obtaining silex	
SECT. II....Experimental proofs of the properties of silex.	191
Experiment I. II. III.....	
IV. V. VI.	192
Formation of glass	193

PART LIX.

ALUMINE.

SECT. I....Natural history of alumine.....	197
Properties of alumine.....	

CONTENTS OF THE SECOND VOLUME.

xi

	Page
Methods of obtaining alumine	198
SECT. II....Experimental proofs of the properties of alumine	200
Experiment I. II. III.	
IV.	201
Methods of making pottery	202

PART LX.

GLUCINE.

SECT. I....Natural history of glucine	204
Properties of glucine	205
Methods of obtaining glucine	
SECT. II....Experimental proofs of the properties of glucine	206
Experiment I. II.	
III. IV.	207

PART LXI.

ZIRCON.

SECT. I.....Natural history of zircon, or jargon	208
Properties of zircon	
Method of obtaining zircon	209
SECT. II....Experimental proofs of the properties of zircon	210
Experiment I. II.	
III.	211
Remarks	

PART LXII.

AGUSTINE.

Natural history of agustine	214
Properties of agustine	

PART LXIII.

YTTRIA.

	Page
Natural history of yttria.....	215
Properties of yttria.....	

PART LXIV.

MAGNESIA.

SECT. I....Natural history of magnesia.....	216
Properties of magnesia	
Method of obtaining magnesia	217
SECT. II...Experimental proofs of the properties of mag- nesia	218
Experiment I. II.....	
III. IV. V. IV.....	219

PART LXV.

ALCALIES.

Enumeration of alcalies	221
General properties of alcalies.....	

PART LXVI.

BARYTES.

SECT. I....Natural history of barytes	222
Properties of barytes	
Methods of obtaining barytes	223
SECT. II...Experimental proofs of the properties of barytes.	224

	Page
Experiment I. II.....	224
III. IV. V. VI.....	225
VII. VIII. IX.	226
X.....	227

PART LXVII.

POTASH.

SECT. I.....Natural history of potash.....	228
Properties of potash	229
Methods of obtaining potash	
Remarks.....	233
SECT. II....Experimental proofs of the properties of potash	234
Experiment I.....	
II. III.....	235
IV. V. VI.....	236

PART LXVIII.

SODA.

SECT. I.....Natural history of soda	237
Properties of soda.....	238
Methods of obtaining soda.....	
SECT. II....Experimental proofs of the properties of soda.	239
Experiment I.	
Formation of soaps.....	240

PART LXIX.

STRONTIA.

SECT. I.....Natural history of strontia	242
Properties of strontia	
Methods of obtaining strontia.....	243

	Page
SECT. II....Experimental proofs of the properties of strontia	244
Experiment I. II.	
III. IV.	245

PART LXX.

LIME.

SECT. I....Natural history of lime	246
Properties of lime	247
Methods of obtaining lime	
SECT. II....Experimental proofs of the properties of lime	249
Experiment I. II.	
III.	250
IV. V.	251
VI. VII.	252
Preparation of mortar and cement	253

PART LXXI.

AMMONIA.

See vol. I.	309
------------------	-----

PART LXXII.

THEORY

OF THE

DECOMPOSITION AND FORMATION

OF

WATER.

SECT. I....Decomposition of water by chemical agencies	255
Decomposition of water by electricity and galvanism	256
SECT. II....Re-composition of water	259

PART LXXIII.

ACIDS.

Formation of acids.....	Page 260
General physical properties of acids.....	261

PART LXXIV.

MURIATIC ACID.

Properties of muriatic acid.....	262
Method of obtaining muriatic acid	263
Properties of muriates	264
Methods of obtaining muriates	

PART LXXV.

BORACIC ACID.

Properties of boracic acid.....	265
Methods of obtaining boracic acid	
Properties of borates.....	266
Methods of obtaining borates	

PART LXXVI.

FLUORIC ACID.

Properties of fluoric acid	267
Methods of obtaining fluoric acid.....	
Properties of fluates	268
Methods of obtaining fluates.....	

PART LXXVII.

OXIGENATED MURIATIC ACID.

	Page
Properties of oxigenated muriatic acid.....	269
Methods of obtaining oxigenated muriatic acid.....	270
Properties of oxigenated muriates.....	271
Preparation of oxigenated muriates	272
<i>Nitro-muriatic acid</i>	

PART LXXVIII.

SULPHURIC ACID.

Properties of sulphuric acid.....	273
Methods of obtaining sulphuric acid.....	274
Properties of sulphates.....	275
Methods of obtaining sulphates.....	

PART LXXIX.

SULPHUREOUS ACID.

Properties of sulphureous acid.....	276
Methods of obtaining sulphureous acid	
Properties of sulphites	277
Methods of obtaining sulphites.....	

PART LXXX.

PHOSPHORIC ACID.

Properties of phosphoric acid.....	278
Methods of obtaining phosphoric acid	279

Properties of phosphates.....	Page 280
Methods of obtaining phosphates.....	

PART LXXXI.

PHOSPHOROUS ACID.

Properties of phosphorous acid	281
Methods of obtaining phosphorous acid.....	
Properties of phosphites.....	282
Methods of obtaining phosphites.....	

PART LXXXII.

CARBONIC ACID.

Properties of carbonic acid	283
Methods of obtaining carbonic acid, see vol. I.	235
Properties of carbonates.....	
Methods of obtaining carbonates	284

PART LXXXIII.

NITRIC ACID.

Properties of nitric acid	285
Methods of obtaining nitric acid.....	
Properties of nitrates	286
Methods of obtaining nitrates	287

PART LXXXIV.

NITROUS ACID.

Properties of nitrous acid	288
Methods of obtaining nitrous acid	289

PART LXXXV.

ARSENIC ACID.

	Page
Properties of arsenic acid	290
Method of obtaining arsenic acid	
Properties of arseniates.....	291
Methods of obtaining arseniates.....	

PART LXXXVI.

ARSENIOUS ACID.

Properties of arsenious acid.....	291
Methods of obtaining arsenious acid.....	
Properties of arsenites	292
Methods of obtaining arsenites.....	

PART LXXXVII.

TUNGSTIC ACID.

Properties of tungstic acid.....	294
Methods of obtaining tungstic acid	
Properties of tungstates.....	
Methods of obtaining tungstates.....	295

PART LXXXVIII.

MOLYBDIC ACID.

Properties of molybdic acid	296
Methods of obtaining molybdic acid.....	297
Properties of molybdates	
Methods of obtaining molybdates.....	

PART LXXXIX.

CHROMIC ACID.

	Page
Properties of chromic acid	298
Methods of obtaining chromic acid	299

PART XC.

COLUMBIC ACID.

Properties of columbic acid	300
Method of obtaining columbic acid	24

PART XCI.

ACETOUS ACID.

Properties of acetous acid	301
Method of obtaining acetous acid	302
Properties of acetites	
Methods of obtaining acetites	

PART XCII.

ACETIC ACID.

Properties of acetic acid	303
Methods of obtaining acetic acid	

PART XCIII.

OXALIC ACID.

Properties of oxalic acid	304
Method of obtaining oxalic acid	
Properties of oxalates	305
Methods of obtaining oxalates	

PART XCIV.

TARTAREOUS ACID.

	Page
Properties of tartareous acid	306
Methods of obtaining tartareous acid	
Properties of tartrites	307
Methods of obtaining tartrites	

PART XCV.

CITRIC ACID.

Properties of citric acid	308
Method of obtaining citric acid	
Properties of citrates	309
Methods of obtaining citrates	

PART XCVI.

MALIC ACID.

Properties of malic acid	310
Methods of obtaining malic acid	
Properties of malates	311
Methods of obtaining malates	

PART XCVII.

GALLIC ACID.

Properties of gallic acid	312
Methods of obtaining gallic acid	313

PART XCVIII.

SUCCINIC ACID.

	Page
Properties of succinic acid	314
Methods of obtaining succinic acid	
Properties of succinates	
Method of obtaining succinates	

PART XCIX.

BENZOIC ACID.

Properties of benzoic acid	315
Methods of obtaining benzoic acid	316
Method of obtaining benzoates	

PART C.

CAMPHORIC ACID.

Properties of camphoric acid	317
Method of obtaining camphoric acid	
Properties of camphorates	
Methods of obtaining camphorates	

PART CI.

MUCOUS,

OR

SACCHO-LACTIC ACID.

Properties of mucous acid	318
Methods of obtaining mucous acid	

PART CII.

SUBERIC ACID.

	Page
Properties of suberic acid.....	319
Method of obtaining suberic acid.....	

PART CIII.

PRUSSIC ACID.

Properties of prussic acid.....	320
Method of obtaining prussic acid.....	
Properties of prussiates.....	323
Methods of obtaining prussiates.....	

PART CIV.

LACTIC ACID.

Properties of lactic acid.....	325
Method of obtaining lactic acid.....	

-PART CV.

SEBACIC ACID.

Properties of sebacic acid.....	326
Methods of obtaining sebacic acid.....	

PART CVI.

LACCIC ACID.

Properties of laccic acid.....	327
Method of obtaining laccic acid.....	

PART CVII.

BOMBIC ACID.

Properties of bombic acid	Page 328
Methods of obtaining bombic acid.....	

PART CVIII.

AMNIOTIC ACID.

Properties of amniotic acid	
Method of obtaining amniotic acid.....	329

PART CIX.

URIC ACID.

Properties of uric acid	330
-------------------------------	-----

 CHEMISTRY OF VEGETATION.

GENERAL VIEW

OF

THE CHEMICAL PHENOMENA

OF

VEGETATION.

Structure of vegetables	Page 331
Phenomena of vegetation.....	332
Food of plants.....	

IMMEDIATE PRINCIPLES

OF

VEGETABLES.

	Page
Mucilage, or gum.....	333
Starch, or fecula.....	334
Jelly.....	
Sugar.....	
Gluten.....	335
Fixed oils.....	
Volatile oils.....	
Camphor.....	336
Wax.....	
Resin.....	
Extract.....	337
Caoutchouc.....	
Acids.....	
Tanin.....	
Colouring matter.....	338
Suber.....	
Wood.....	

SPONTANEOUS CHANGES

OF

VEGETABLES.

1. Vinous fermentation.....	339
Wine.....	340
Beer.....	
Alcohol.....	341
2. Acetous fermentation.....	343
Vinegar.....	344
3. Putrefactive fermentation.....	

 CHEMISTRY OF ANIMAL SUBSTANCES.

 GENERAL EXAMINATION
 OF
 ANIMAL SUBSTANCES.

	Page
Bones.....	345
Muscles.....	
Membranes.....	346
Ligaments.....	
Tendons.....	
Skin.....	
Fat, tallow, and marrow.....	
Nails.....	347
Horns and hoofs.....	
Hair.....	
Feathers.....	
Shells.....	
Blood.....	
Milk.....	348
Saliva.....	
Tears.....	
Mucus of the nose.....	
Bile.....	
Biliary calculi.....	
Urine.....	
Urinary calculi.....	349
Wax of the ear.....	
Tracheal humours.....	
Sinovia.....	
Seminal fluid.....	

	Page
Liquor of the amnios.....	349
Cerebral pulp.....	
Perspirable matter.....	350
Humour of the prostata.....	
Chyle, and pancreatic and gastric juices	
Intestinal gas	

SPONTANEOUS DECOMPOSITION OF ANIMAL MATTER.

A LIST OF CHEMICAL PREPARATIONS,

Prepared and Sold, in as pure a State as possible, by

Messrs. ACCUM and Co. Old Compton Street, Soho.

METALS.—Arsenic, Tungsten, Molybdena, Cobalt, Nickel, Bismuth, Antimony, Mercury, Zinc, Tin, Lead, Iron, Copper, Silver, Gold, Platina.

Collections of Ores, containing the preceding Metals, in their native state, systematically arranged.

ACIDS—Arsenic, Arsenious, Tungstic, Molybdic, Acetous, Acetic, Oxalic, Tartareous, Citric, Malic, Gallic, Succinic, Benzoic, Camphoric, Mucous, Suberic, Prussic, Lactic, Sebacic, Fluoric, Boracic, Muriatic, Oxygenated-Muriatic, Phosphoric, Nitric, Nitrous, Sulphuric, &c.

ALCALIES—Barytes, Potash, Soda, Strontia, Lime, Ammonia.

EARTHS—Silice, Alumine, Magnesia, Zircon, Glucine, &c.

RE-AGENTS—Tincture of Cabbage, Litmus, Turmeric, Brazil-wood, and Galls.

Papers tinged with each of these Tinctures.

Tincture of Cabbage, and Tincture of Litmus reddened by Acetous Acid.

Barytic, Strontia, and Lime-water.

Oxalate of Ammonia, Acidulous Oxalate of Potash, and Oxalate of Soda.

Fluate of Soda, and Fluate of Ammonia.

Carbonate of Potash, Carbonate of Soda, and Carbonate of Ammonia.

Acetite and Nitrate of Lead.

Muriate of Gold, Muriate of Tin, and Muriate of Mercury.

Sulphate, Nitrate, and Acetite of Silver.

Green and Red Sulphate of Iron.

Muri-

Muriate, Nitrate, and Acetite of Barytes.

Triple Prussiate of Potash, Lime, and Ammonia.

Tanin, Alcohol, Sulphuric and Nitric Ether.

Solution of Soap, Solution of Arsenic, Solution of Gelatine.

Sulphuret of Potash, Sulphuret of Lime, and Sulphuret of Magnesia.

Hidro-Sulphuret of Ammonia.

Glacial Acid of Phosphorus. Phosphate of Soda and Ammonia.

Black, and White Flux, &c. &c.

ALL THE DIFFERENT GASES—Water impregnated with Sulphurated Hydrogen Gas, with Carbonic Acid Gas, with Carbonated Hydrogen Gas, &c.

PHOSPHORUS—Phosphuret of Lime, Phosphuret of Strontia, and Phosphuret of Barytes. Phosphorated Ether, Phosphorated Alcohol, and Phosphorated Oils.

HYPER-OXIGENATED MURIATE of POTASH, and Hyper-oxygenated Muriate of Lime, for bleaching.

FULMINATING GOLD, Fulminating Silver, and Fulminating Mercury.

CHEMICAL CHESTS, containing a select Collection of Re-Agents, for analyzing stones, ores, mineral waters, earths, soils, &c.

PORTABLE LABORATORIES, including all the preparations and apparatus necessary for the analysis of natural and artificial products.

CHESTS OF RECREATION, containing a Collection of Chemical Articles, for performing a variety of striking and interesting experiments.

And every other Article not in general demand, either for Philosophical, Technical or Medicinal use.

APPARATUS AND INSTRUMENTS.

PORTABLE UNIVERSAL FURNACES, made of strong iron plates, lined with fire-bricks, calculated for all chemical operations whatever, which require the aid of heat.

Black Lead Table Furnaces—**Portable Forges**—**Brass Lamp-Furnaces**, on an improved plan, with double cylindrical cottons and Argand lamp.

IMPROVED GAZOMETERS, with Glass Bells—**Brass Stop-cocks**, &c. for collecting, measuring, breathing, transferring gases. &c.

Gas-Holders—**Pneumatic Cisterns**—**Improved Mercurial Troughs**, with sliding shelf and tray.

GLASS RECEIVERS, mounted with brass stop-cock, for transferring gases into bladders, &c.

Globular Receivers and Flasks, with stop-cocks, for weighing gases.

PORTABLE STILLS and REFRIGERATORIES of Tinned Copper. Glass Alembics. Retorts and Receivers.

GRADUATED DETONATING TUBES for firing gases. &c.

Deflagrating Jars—**Improved Blow-pipes of Metal and Glass**, **Eolipile-Blow-pipes**.

SPOONS of GOLD, SILVER, and PLATINA.

MORTARS of Iron, Steel, Agate, Flint, Glass, Wedgwood Ware, &c.

CRUCIBLES of Platina, Gold, Silver, Cast Iron, &c.—**Muffles, Cupels, and Enamelling Pans**—**Improved Ingots and Casting Cones**, **Evaporating Basins**—**Guiton's Tubes of Safety**—**Syphons**—**Jointed Conducting Tubes**—**Graduated Glass Measures and Cubic Inches**—**Accurate Balances and Weights in Decimals**—**Thermometers**—**Goniometers**—**Gravimeters**—**Galvanic Batteries, Piles, Plates, &c.**—**Wollaston's Apparatus for decomposing Water by Galvanism, or Electricity**; and every other Instrument made use of in Experimental Chemistry.

A
SYSTEM
OF
THEORETICAL AND PRACTICAL
CHEMISTRY.

PART XXXIII.

METALS.

AMONG the simple substances which present themselves to our view in examining the products of nature, there are none of which the study is more important than METALS. Their utility is highly interesting. They may be considered as the great instruments of human industry. Many of the mechanic arts could not possibly exist without them, and it is even doubtful whether mankind, would have acquired that degree of civilization which characterizes the present state of society.

ENUMERATION OF METALS.

We are at present acquainted with twenty-two metals, essentially differing from each other, namely,

Arsenic	Antimony
Tungsten	Tellurium
Molybdena	Mercury
Chrome	Zinc
Columbium	Tin
Titanium	Lead
Uranium	Iron
Cobalt	Copper
Nickel	Silver
Manganese	Gold
Bismuth	Platina.

We abandon the ancient division of these substances into noble or perfect, and semi or imperfect metals, but class them into different genera; proceeding in a gradation from those which possess, in a certain sense, the *least*, to those which possess the *most* metallic properties.

CLASSIFICATION OF METALS.

1. *Very brittle and acidifiable metals.*

Arsenic	Molybdena
Tungsten	Chrome
Columbium.	

2. *Less brittle and simply oxidable metals.*

Titanium	Manganese
Uranium	Bismuth
Cobalt	Antimony
Nickel	Tellurium.

3. *Partly ductile and oxidable metals.*

Mercury

Zinc.

4. *Very ductile and easily oxidable metals.*

Tin

Lead

Iron

Copper.

5. *Exceedingly ductile and difficultly oxidable metals.*

Silver

Gold

Platina.

NATURAL HISTORY OF METALS.

All the metals are found in the bowels of the earth, though sometimes they are on the surface. They are met with in different combinations with other matters, such as sulphur, oxygen, and acids; particularly with the carbonic, muriatic, sulphuric and phosphoric acids. They are also found combined with each other, and sometimes, though rarely, in a pure metallic state, distinguishable by the naked eye.

In their different states of combination they are said to be mineralized, and are called ORES. The ores of metals are for the most part, found in nature in mountainous districts; and always in such as form a continued chain. There are mountains which consist entirely of iron ore, but in general the metallic part of a mountain bears a very inconsiderable proportion to its bulk. Ores are also met with in the cavities or

crevices of rocks, forming what are termed **VEINS**, which are more easily discovered in these situations than when they lie level in plains.

The metallic matter of ores is very generally incrustated and intermingled with some earthy substance different from the rock in which the vein is situated; which is termed its **MATRIX**. This, however, must not be confounded with the mineralizing substance with which the metal is combined, such as sulphur, &c.

The art of distinguishing ores and the method of describing them with accuracy and precision, so that they may be known from each other, is called **MINERALOGY**.

The art of assaying or analysing them, in order to ascertain their component parts, particularly their metallic contents, forms a branch of chemistry, called the **DOCIMASTIC ART**.

The art of extracting metals in the large way is called **METALLURGY**.

GENERAL PHYSICAL PROPERTIES OF METALS.

All metals are combustible bodies. They possess a certain brilliancy, in consequence of the complete reflection of the light that falls upon them, which is termed *metallic lustre*. They are the most dense and heavy substances in nature; the heaviest fossil, not metallic, having a specific gravity much below that of the lightest metal. They are the most opaque of all bodies. A stone of the greatest opacity, when divided into thin plates, has more or less transparency; whereas gold is the only metal which admits of being reduced to such a degree of thinness as to admit the smallest perceptible transmission of light. Gold leaf, which is about $\frac{1}{280000}$ part of an inch in thickness, transmits light of a lively green colour; but silver, copper and all the rest of the metals are perfectly opaque. Another property which belongs exclusively to metals, (though they do not all possess it,) is *malleability*; by which is meant a capacity of having their surface

increased, either in length or breadth, without being liable to fracture. This capacity is not precisely the same in those metals which do possess it, for some, which admit of extension when struck with a hammer, cannot be drawn into wire, which property is termed *ductility*: this property depends in some measure on another peculiar quality of metals, namely *tenacity*; by which is meant the power which a metallic wire of a given diameter has of resisting the action of a weight suspended from its extremity. All metals are fusible, though the degree of temperature at which this can be effected differs very much. Mercury is always fluid at the ordinary temperature of our atmosphere, while platina can scarcely be melted by the most intense heat of our furnaces. Metals are perfectly opaque when in a state of fusion; and are crystallizable when suffered to cool slowly and undisturbed. The tetrahedron and the cube are their primitive figures, though they very often take the octahedral form. They can likewise be volatilized at very high temperatures. They are the best conductors of caloric and electricity. Their susceptibility of combination is very great; they unite with carbon, sulphur, and phosphorus. They do not combine with earths by fusion; but their oxids readily unite to acids, alcalies and earths. They decompose water and several acids. Some effect this at common temperatures: some require a red-heat, and others the interposition of another body. Water does not dissolve any of the metals, though it is a solvent of some of their oxids. They are insoluble in ardent spirit, ether, or oils. They are all capable of combining with oxygen, though many of them require very high temperatures to effect this union, and others cannot be united to it but in an indirect manner. Most of the metals can be combined with each other; they then form alloys, many of which are of the greatest utility in the arts.

Class I...BRITTLE AND ACIDIFIABLE METALS.

ARSENIC.

PART XXXIV.

SECT. I.

NATURAL HISTORY OF ARSENIC.

ARSENIC is scattered in great abundance over the mineral kingdom. It is found in black heavy masses of little brilliancy, called *native arsenic*, (testaceous arsenic.) It is found in different parts of Germany. Mineralized by sulphur, it forms *sulphurized arsenic*, or *orpiment*. This mineral is met with in Italy, about Mount Vesuvius. There are two varieties of this ore which differ from each other in colour, occasioned by the different proportions of its component parts. The one is called yellow *sulphurized arsenic*, or *orpiment*; the other, red *sulphurized arsenic*, or *realgar*, (*ruby arsenic*); both are met with in Hungary and different parts of Germany. The colour of the first ore is a lemon yellow, inclining sometimes to a green; the

colour of the latter is a ruby red; it is more transparent than the former, and found in compact solid masses, sometimes crystallized in bright needles. Arsenic united to oxygen constitutes the ore called *native oxid of arsenic*. This ore is scarce; it is generally found of an earthy appearance, or as an efflorescence, coating native, or metallic arsenic; its colour is a whitish grey; it is rarely met with crystallized. Arsenic exists likewise alloyed with cobalt, antimony, tin, copper, lead, and various other metals.

PROPERTIES OF ARSENIC.

Arsenic is a brittle metal, and in the recent fracture of a lively bright colour, between tin-white and lead-grey; but, on exposure to the air, it soon loses its metallic lustre, and turns prismatic, dull, and at last black. Its specific gravity is between 8.310 and 5.763 according to its texture. Its hardness surpasses that of copper; but its ductility is so little and its brittleness so great that it is readily converted into a powder by the hammer. It is entirely volatilized when heated to 356° Fahr. It sublimes in close vessels, and then crystallizes in tetrahedra, or octahedra. When heated with the access of air, it emits a strong smell of garlic, and burns with a bluish white flame. It combines with sulphur by fusion. It unites to phosphorus and combines with most of the metals. It gives a white colour to copper and renders many of the ductile metals brittle. When mixed with hyper-oxygenated muriate of potash, it detonates strongly by the stroke of a hammer. It is soluble in hydrogen gas by heat. It does not decompose water alone. It decomposes sulphuric acid by heat. The nitric and nitrous acids oxidate it rapidly. The muriatic acid attacks it with heat. The oxygenated muriatic acid when in a gaseous state inflames it instantly. It is nearly unalterable by the fluoric, boracic, phosphoric and carbonic acids. It unites with alkaline sulphurets and hidro-sulphurets. It is a deadly poison.

METHOD OF OBTAINING ARSENIC.

In order to obtain metallic arsenic, mix two parts of the white oxid of arsenic of commerce, with one of black flux (obtained by detonating one part of nitrate of potash with two of acidulous tartrate of potash) and put the mixture into a crucible or melting pot. Invert over this, another crucible, lute the two together with a little clay and sand, and apply gradually a red heat to the lower one. The oxid of arsenic will be reduced and be found lining the upper crucible in small crystals of a metallic brilliancy.

RATIONALE...The charcoal of the black flux takes the oxygen from the white oxid, and forms carbonic acid gas; which flies off during the process, and the oxid becomes reduced to the metallic state. This reduction of the oxid is greatly facilitated by the alkali of the flux.

REMARK...In order to obtain arsenic in a state of absolute purity, the metal before obtained must be reduced to powder, dissolved by heat in nitro-muriatic acid, and then precipitated by immersing into the solution a plate of zinc. The arsenic is thus precipitated in a fine powder, and may be reduced to its metallic state, by exposing it in a covered crucible to a moderate heat.

If it be kept under water its metallic brilliancy may be preserved. This effect is still better produced by alcohol.

SECT. II.

EXPERIMENTAL PROOFS

OF

THE PROPERTIES OF ARSENIC.

EXPERIMENT I.

Arsenic burns and is volatilized by heat.

INTRODUCE into a crucible, made red-hot in a coal-fire, a small quantity of arsenic ; it will soon begin to burn and become volatilized.

If this crucible be covered with another, and the joinings luted with a little clay, the arsenic will be found in the upper one in brilliant crystals.

EXPERIMENT II.

Arsenic stains copper white.

Insert a little arsenic, reduced to fine powder, between two polished plates of copper ; bind them closely together with iron wire and heat them. The inner surfaces of the copper plates will be rendered white by the arsenic.

The union of arsenic with copper may likewise be effected by fusing one part of arsenic and four of copper, in a common crucible. The alloy produced is a white metal.

REMARK...It is necessary in this experiment to cover the substances in the crucible with common salt, to prevent the action of the air.

EXPERIMENT III.

Arsenic decomposes sulphuric acid.

Put into a retort one part of arsenic reduced to a fine powder and three of sulphuric acid, direct the neck of the retort under a receiver filled with mercury, in the mercurial pneumatic trough, and apply the heat of a lamp. When the mixture has boiled some time, sulphureous acid gas will pass into the receiver.

RATIONALE...The arsenic subtracts the oxygen of part of the sulphuric acid, which becomes converted into sulphureous acid gas. The oxid of arsenic which is produced, is dissolved in the other part of the acid.

EXPERIMENT IV.

Arsenic combines readily with sulphur.

If one part of arsenic and four or five of sulphur be hastily fused together in a well closed crucible, the two substances unite and form a yellow compound, called sulphuret of arsenic.

EXPERIMENT V.

Arsenic combines with phosphorus.

Put equal quantities of arsenic, reduced to powder, and phosphorus, into a Florence flask; pour water upon them, so as to cover them an inch, and apply the gentle heat of a lamp. The

arsenic and phosphorus will unite and form a phosphuret of that metal.

This combination may likewise be conveniently effected, by gently heating, in a close phial, equal parts of phosphorus and pulverized arsenic.

EXPERIMENT VI.

Tin and arsenic may be alloyed by fusion.

Put into a crucible placed in a fire, seven parts of tin and one of arsenic, melt the mixture and when completely united pour it out into an ingot. The alloy obtained will be found to be of a white colour, it is much harder, more sonorous, and less fusible than tin.

EXPERIMENT VII.

Arsenic detonates with hyper-oxygenated muriate of potash by percussion.

Put a few grains of arsenic in contact with hyper-oxygenated muriate of potash, on an anvil or any smooth solid surface, and give it a smart blow with a hammer. The mixture will explode with a loud report.

The spontaneous accension of arsenic in oxygenated muriatic acid gas has been exemplified already (page 338).

ANALYSIS OF ORES OF ARSENIC.

Take any quantity of the ore, reduce it to powder, and introduce it into a Florence flask, pour over it three times its own weight of nitro-muriatic acid, composed of one part of nitric,

and one and a half of muriatic acid; assist the action of the acid by the heat of a lamp or candle. When no further action ensues, if the ore is not completely dissolved, add a fresh quantity of acid, and proceed as before till all is dissolved. Then let the solution subside, (for if the arsenical ore contained silver, a white heavy precipitate will be formed during the process,) filtre it, and evaporate it in a Wedgwood's bason to at least one-fourth. When so far concentrated add distilled water to the solution, so long as it occasions any turbidness, which may be known by filtering, from time to time, a small quantity of the mixture, and assaying the filtered fluid by a fresh addition of water. The white precipitate which is thus obtained is the quantity of arsenic which was contained in the ore. In order to reduce it to the metallic state it may be re-dissolved in muriatic acid, and precipitated by immersing into this solution a plate of zinc, mixing with it at the same time a tenth part of a solution of alcohol.

If the ore contained silver the white precipitate mentioned before must be dried, and then mixt with double its weight of carbonate of soda freed from its water of crystallization, and exposed in a crucible to a white heat for at least half an hour. The silver will be found at the bottom of the crucible in a metallic state.

The sulphurated ores of arsenic may be analyzed in a similar manner, by treating them with nitro-muriatic acid. In this case an addition of acid will not dissolve the residue. The arsenic may be separated, by first concentrating the solution, and then adding to it water. The sulphur may then be collected on a filter, and dried between bibulous paper in a heat not above that of boiling water. If it be pure sulphur, it may be volatilized by a continued gentle heat.

TUNGSTEN.

PART XXXV.

NATURAL HISTORY OF TUNGSTEN.

THIS metal, which is never found but in combination, is by no means common. The substance known to mineralogists under the name of tungsten was, after some time, discovered to consist of lime, combined with a peculiar acid or metallic oxid. This ore is now called *tungstate of lime* and is exceedingly scarce. It has been found in Sweden and Germany, both in masses and crystallized, of a yellowish white, or grey colour. It has a sparry appearance, is shining, of a lamellated texture, and semi-transparent. The same metallic acid is likewise found united to iron and manganese; it then forms the ore called Wolfram, or *tungstate of iron and manganese*. This ore occurs both massive and crystallized, and is found in Cornwall, Germany, France, and Spain. Its colour is brownish black, and its texture foliated. It has a metallic lustre, and a lamellated texture; it is brittle and very heavy; it is found in solid masses in the state of layers interspersed with quartz. These two substances are therefore ores of the same metal.

PROPERTIES OF TUNGSTEN.

Tungsten appears of a steel grey colour. Its specific gravity is about 17.6. It is one of the hardest metals, but it is exceedingly brittle; and is said to be almost as infusible as platina. Heated in the air it becomes converted into a yellow pulverulent oxid, which becomes blue by a strong heat or when exposed to light. Tungsten combines with phosphorus and sulphur, and with silver, copper, iron, lead, tin, antimony, and bismuth; but it does not unite with gold and platina. It is not attacked by the sulphuric, nitric, or muriatic acids; nitro-muriatic acid acts upon it very slightly. It is oxidable and acidifiable by the nitrates and super-oxygenated muriates. It colours the vitrified earths or the vitreous fluxes, of a blue or brown colour. It is not known what its action will be on water and different oxids. Its action on the alcalies is likewise unknown. It is not employed yet, but promises real utility, on account of its colouring property, as a basis for pigment, since the compounds it is said to form with vegetable colouring matters afford colours so permanent as not to be acted on by the most concentrated oxygenated muriatic acid, the great enemy of vegetable colours.

METHODS OF OBTAINING TUNGSTEN.

The method of obtaining metallic tungsten is a problem in chemistry. Scheele, Bergman, and Gmelin did not succeed in their attempts to procure it. Klaproth* tried to reduce the yellow oxid of this metal with a variety of combustible substances, but without success. Messrs. Ruprecht and Tondy† say they have obtained this metal by using combustible substances alone; and by a mixture of combustible and alkaline matter.

* Crell's Annal, 1786, vol. II, p. 502. † Ann. de Chem. tom. VIII, p. 4.

The following process is recommended by Richter, an ingenious German chemist.*

Let equal parts of tungstic acid and dried blood be exposed for some time to a red-heat in a crucible; press the black powder which is formed into another smaller crucible, and expose it again to a violent heat in a forge for at least an hour. Tungsten will then be found, according to this chemist, in its metallic state in the crucible.

REMARK...This author very properly objects to the use of alcalies or alkaline salts in this process as they are apt to form neutral salts with the tungstic acid and in this way prevent its reduction. From the facility however with which Ruprecht and Richter seem to have obtained this metal it may fairly be questioned whether it was intirely free from all admixtures.

The existence of metallic Tungsten being doubtful, we must content ourselves, with examining the properties of this substance in the state of an oxid, for which we refer the reader to the article *Tungstic acid*.

The same must be the case with those metals which possess few metallic properties; or whose scarcity has hitherto prevented chemists from experimenting upon them; when a sufficient quantity of the ores can be procured, their characters and properties will no doubt be investigated. Hitherto chemists have paid attention to them when in combination with oxigen, or when they are brought to the state of an acid; we are consequently unable to say much about their metallic properties in the present state of our knowledge.

We are inclined to believe with Mr. Hatchett† that the time is perhaps not very far distant, when some of the newly discovered metals, which are now considered as simple, primitive, and distinct bodies, will be found to be compounds; but until that happens we are obliged to consider them as substances *sui generis*.

* Richter über die Neuen Gegenstände der Chemie, 1 Stück, p. 49.

† Nicholson's Journal, July, 1802, p. 179.

ANALYSIS OF ORES OF TUNGSTEN,

Tungstate of lime may be treated (like ores of arsenic) repeatedly with nitro-muriatic acid, till every thing soluble is taken up. The tungsten will thus be converted into a yellow oxid, distinguishable from the oxid of uranium, by its becoming white on the addition of liquid ammonia. The alumine which was contained in the ore may be separated by adding to the acid solution some carbonate of ammonia.

Ores of wolfram may be analyzed in the following manner. Take one part of the ore, reduce it to a powder, and digest it for at least an hour in four or five parts of muriatic acid; decant the acid, wash the residue in distilled water, and pour over it two parts of liquid ammonia, suffer it to stand for a few days, taking care to agitate it frequently. Then decant the ammonia, digest the residue again, alternately in muriatic acid, and ammonia till the whole is dissolved. Evaporate the ammoniacal solutions in a glass bason to dryness, transfer the dry mass into a Wedgwood's crucible, and ignite it strongly. The product thus obtained is the yellow oxid of tungsten.

The muriatic solutions may then be likewise added together and mingled with one sixth part of sulphuric acid, evaporated to dryness, and re-dissolved in water: on adding a solution of carbonate of ammonia a precipitate will be obtained which consists of the iron and manganese contained in the ore. It may therefore be digested in acetous acid; the manganese will then become dissolved, and the iron remain behind. Finally, on adding an alkali the manganese will be precipitated, and the analysis will be complete.

MOLYBDENA.

PART XXXVI.

NATURAL HISTORY OF MOLYBDENA.

MOLYBDENA exists mineralized by sulphur in the ore called *sulphuret of Molybdena*. This ore, which is likewise scarce, is so similar in several of its properties to plumbago that they were long considered as varieties of the same substance. It is of a light lead-grey colour, its surface is smooth, and feels unctuous, its texture is lamellated, it soils the fingers, and marks paper bluish-black, or silver-grey. It may be cut with a knife. It is generally found in compact masses; seldom in particles, or crystallized. It is met with in Sweden, Spain, Saxony, Siberia and Iceland. Scheele showed that a peculiar metallic acid might be obtained from it; and later chemists have succeeded in reducing this acid to the metallic state. We are indebted to Mr. Hatchett, for a full and accurate analysis of this ore.*

VOL. II.

B

* See his valuable paper on the analysis of the Corinthian Molybdate of Lead. Phil. Trans. 1796.

The native *sulphuret of molybdena*, is the only ore hitherto known which contains this metal.

PROPERTIES OF MOLYBDENA.

Molybdena is either in an agglutinated blackish friable mass, having little metallic brilliancy, or in a black powder. The mass slightly united shows by a magnifying glass, small round brilliant grains. Its weight is from 6.600 to 7.500. It is one of the most infusible of the metals. It is capable of combining with a number of metals by fusion. It forms with sulphur an artificial sulphuret of molybdena analogous to its ore. It unites also to phosphorus, The affinity of molybdena for oxygen is very feeble, according to Mr. Hatchett. The alcalies have no action on molybdena in the moist way, but it enters readily into fusion with potash and soda. It is oxidable by boiling sulphuric acid, and acidifiable by the nitric acid. Muriatic acid does not act upon it. It is capable of existing in not less than four different degrees of oxygenation.

METHOD OF OBTAINING MOLYBDENA.

To obtain molybdena is a task of the utmost difficulty. Few chemists have succeeded in producing this metal on account of its great infusibility. The method recommended in general is the following :...Molybdic acid is to be formed into a paste with oil, dried at the fire, and then exposed to a violent heat in a crucible lined with charcoal. By this means the oxid becomes decomposed ; a black agglutinated substance is obtained very brittle under the finger, and having a metallic brilliancy. This is the metal called molybdena.

ANALYSIS OF ORES OF MOLYBDENA.

Take one part of the ore reduced to powder, put it into a tubulated retort, containing three parts of nitric acid, adapt a receiver, and distil till no more drops fall from the neck of the retort. Having done this, pour again two ounces of nitric acid upon the ore in the retort, stir it well together with a glass rod, and repeat the distillation as before. This treatment must be repeated until the whole of the ore is converted into a white powder.

This powder, after being well washed in distilled water, is molybdic acid. The water used for the ablution of this acid, must then be mingled gradually with small quantities of a solution of potash; by this means an additional portion of white precipitate will be obtained, which after being washed, may be added to the first. This being separated, muriate of barytes is to be added to the fluid as long as any precipitate ensues: 100 parts of this precipitate indicate 14.5 of sulphur. The quantity of sulphur, as well as that of molybdena may thus be ascertained.

The sulphuret of molybdena may likewise be analyzed by mixing one part of the ore with four of nitrate of potash, and detonating the mixture, by transferring it in small quantities into a crucible kept red-hot in a fire. The product must then be dissolved in water, and saturated with nitric acid. The precipitate which is obtained, after being washed, is molybdic acid.

The first process, however, is to be preferred.

CHROME.

PART XXXVII.

NATURAL HISTORY OF CHROME.

THIS metal which is extremely scarce and exists only in the state of a metallic oxid, was discovered by Vauquelin. He found it in an ore called red lead ore of Siberia, or *chromate of lead*. The colour of this ore is red with a shade of yellow; when reduced to powder it is of a bright orange. Chrome has likewise been found in combination with iron, alumine, and silex, (*chromate of iron and alumine*,) in the department of Var in France. It is met with in irregular masses. Its colour is brown; it has very little metallic lustre. Pontier* has lately found chrome combined with iron, (*Chromate of iron*,) in a quarry near Gussin in the road to Cavalaire. It sometimes forms large masses. The emerald of Peru and spinel ruby owe their colours to this metal.

PROPERTIES OF CHROME.

Chrome is obtained in small agglutinated masses of a white colour, inclining to yellow; it is very hard, extremely brittle and refractory, and crystallizes into needles.

* Bulletin de Sciences, No. LVII.

Exposed to the heat of a blow-pipe it is covered with a lilac coloured crust which becomes green on cooling. Heated by the same apparatus with borax, it does not melt; but a part, after being oxidated, is dissolved in this salt and communicates to it a very beautiful green colour. Acids have only a weak action on this metal. The nitric is the only acid which produces any remarkable change, it converts it into an oxid. It is capable of combining with three different portions of oxygen, and forming three different oxids. It has not yet been combined with any combustible body. It does not appear to decompose water. It is unalterable by the alcalies. The other properties of this metal are not yet ascertained, neither are its uses known; perhaps it may afford beautiful and durable colours to the painter or the enameller.

METHOD OF OBTAINING CHROME.

Chrome is obtained from its native combinations by decomposing them by the alkaline carbonates, precipitating the chromic acid and heating it strongly in a crucible.

The following method is recommended by Vauquelin. Seventy two parts of chromic acid, (the preparation of which shall be noticed immediately) are to be introduced into a charcoal crucible placed within another of porcelain filled with charcoal dust. The apparatus is then to be put into a furnace and subjected to a very strong heat. Metallic chrome will then be found in the charcoal crucible. From seventy two parts, Vauquelin obtained forty three of metal.

ANALYSIS OF ORES OF CHROME.

The *red lead ore of Siberia*, or *chromate of lead*, may be analyzed by boiling one part of the ore reduced to a fine powder, with three of carbonate of potash, in six or eight parts of water. The acid of chrome contained in the ore, combines by this

means, with the potash, and the carbonic acid of the latter unites to the lead, and forms an insoluble compound (carbonate of lead.) In order to ascertain its quantity, put it into a flask, and dissolve it, by heat, in nitric acid. On letting sulphuric acid fall into this solution, sulphate of lead will be formed, which may be decomposed by ignition with soda.

Or, the chromate of lead may be treated with muriatic acid; in that case, muriate of lead precipitates, and the chromic acid remains in solution. This process must be repeated until the whole of the ore is decomposed. The solution then contains chromic acid mixt with a little muriatic acid. From the latter it may be freed by dropping into it a solution of nitrate of silver. Muriate of silver will be formed, which, when collected on a filter and dried, may be reduced to the metallic state, by fusing it with double its weight of soda.

The *chromate of iron* may be analyzed in the following manner: Let one part of the ore mixt with eight times its weight of potash, be fused in a crucible for at least one hour. Pour the mass into a convenient vessel, and when cold, boil it in a sufficient quantity of water, for a quarter of an hour, and filter it. The residue which remains on the filter must be transferred into muriatic acid, and digested for a few minutes. The acid is then to be separated by filtration, and the residue treated as before, alternately with potash, and muriatic acid, until the whole is dissolved. The alkaline solutions must then be added together, and the same must be done with the acid ones. The first solutions contain the chromic acid of the ore, and the latter the iron, together with a little chromic acid. In order to free it from it, a solution of carbonate of potash may be dropt into it, and the precipitate boiled for a few minutes in a solution of potash. What remains is pure oxid of iron. The chromic solution must now be saturated, by gradually adding nitric acid, and then be decomposed, by adding nitrate of lead. The precipitate which ensues is chromate of lead, 100 parts of it indicate 35 of chromic acid.

COLUMBIUM.

PART XXXVIII.

NATURAL HISTORY OF COLUMBIUM.

TO the acidifiable metals, which have been sometime known to the chemical world, we have to add one, of a more recent discovery, called Columbium, for which we are indebted to Mr. Hatchett, who discovered it in the year 1802.* This accurate analyst, being engaged in examining and arranging some minerals in the British Museum, observed a specimen of ore which greatly resembled the Siberian chromate of iron. It appeared that the mineral in question was sent from the mines of Massachusetts in North America.

Mr. Hatchett describes this ore as being of a dark brownish grey externally, and more inclining to an iron grey internally; the longitudinal fracture, he found, lamellated; and the cross fracture had a fine grain. Its lustre was vitreous, slightly inclining in some parts to metallic; moderately hard and very brittle. The colour of the streak or powder was dark chocolate brown. The

B 4

* Philosophical Transactions, 1802. Part I. p140.

particles were not obedient to the magnet. Its specific gravity, at a temperature of 65° Fahr. Mr. Hatchett found to be 5.918.

A series of accurate experiments made by its discoverer, prove that this ore consists of iron combined with a new metallic acid, which constitutes more than three-fourths of the whole.

The smallness of the quantity Mr. Hatchett had to operate upon, has hitherto prevented us from seeing the metal in its metallic state; but the accuracy with which the properties of its acid have been investigated, leave no doubt of its being different from any of the acidifiable metals hitherto known.

ANALYSIS OF THE ORE OF COLUMBIUM.

Mr. Hatchett analyzed the columbate of iron, in the following manner:

One part of the ore reduced to powder was mixt with five times its weight of carbonate of potash, and fused in a silver crucible. An effervescence took place during this process. When this had subsided the whole was poured into a proper vessel and suffered to cool. Boiling distilled water was then poured upon it, and the whole was transferred upon a filter. The insoluble residuum was repeatedly washed in distilled water. The filtered fluid was now supersaturated with nitric acid. The result of which was, a white flocculent precipitate (columbic acid).

The insoluble residue was again fused with carbonate of potash and treated as before, but scarcely any effect was thus produced, the alkali was therefore washed off, and the powder digested with muriatic acid, in order to get rid of the iron. The acid was then decanted, and the residuum washed in distilled water. It was again fused with carbonate of potash, dissolved, and precipitated with nitric acid. The residuum was repeatedly treated in a similar manner, till the whole was completely decomposed.

The muriatic solution was decomposed by ammonia. A copious ochraceous precipitate was obtained, which was dissolved in

cold diluted nitric acid. A small quantity of a white insoluble substance, similar to that which was obtained from the alkaline solution, was separated during this process. From this nitric solution Mr. Hatchett obtained by means of ammonia, a precipitate of oxid of iron.

The different alkaline solutions which had been made subsequent to that which has been first mentioned, were mixt together, and being super-saturated with nitric acid, yielded the same white insoluble precipitate. The fluid from which this precipitate had been separated by nitric acid, was then saturated with ammonia, and being boiled afforded about two grains of oxid of iron.

200 grains of the ore thus analyzed, yielded to Mr. Hatchett
42 of oxid of iron, and
155 columbic acid, the properties of which will
be noticed under that article.

Such were the products obtained in the analysis; but as Mr. Hatchett was confined to experiment upon a small quantity of this ore, and could not repeat his researches, without destroying the remaining part of the only specimen at present known; he does not wish the above stated proportions of the component parts of the ore, to be considered as absolutely exact.

Class II....LESS BRITTLE AND SIMPLY OXIDABLE METALS.

TITANIUM.

PART XXXIX.

NATURAL HISTORY OF TITANIUM.

THIS is likewise a newly discovered metal. It was first noticed by Macgregor as existing in the state of an oxid, mixed with iron, manganese, and silex, in a greyish black sand found in the vale of Menachan in Cornwall, and thence named *Menachanite*, or *oxid of Titanium, combined with iron*. It has since been discovered by Klaproth, in an ore named *Titanite*, or *oxid of Titanium, combined with lime and silex*. This ore is generally met with crystallized in four-sided prisms, not longer than a quarter of an inch. Its colour is a yellowish red, or blackish brown; it is opaque and of an imperfect lustre. It breaks with a foliated, uneven, or conchoidal fracture. It exists also in an ore called *Red schorl of Hungary*, or *red oxid of Titanium*. This ore, which is found generally crystallized in rectangular prisms, is of a brownish red colour; and its texture foliated. In all these ores titanium exists in the state of an oxid.

PROPERTIES OF TITANIUM.

Titanium has been only obtained in very small agglutinated grains. It is of a red-yellow and crystalline texture, brittle and extremely refractory. Its specific gravity is about 4.2; when broken with a hammer while yet hot from its recent reduction it shows a change of colours of purple, violet, and blue. In very intense heat it is volatilized. Most of the acids have a striking action on this metal. Nitric acid has little effect upon it. It is very oxidable by the muriatic acid. It is not attacked by the alkalies. Nitro-muriatic acid converts it into a white powder. Sulphuric acid when boiled upon it is partly decomposed. It is one of the most infusible metals. It does not combine with sulphur, but it may be united to phosphorus.* It does not alloy with copper, lead, or arsenic, but combines with iron.

METHOD OF OBTAINING TITANIUM.

It is extremely difficult to reduce the oxid of titanium to the metallic state. However the experiments of Klaproth, Hecht and Vauquelin, have proved its reducibility. According to the two latter, one part of oxid of titanium is to be melted with six of potash; the mass when cold is to be dissolved in water. A white precipitate will be formed which is carbonate of titanium. This carbonate is then made into a paste with oil, and the mixture is put into a crucible filled with charcoal powder and a little alumine. The whole is then exposed for a few hours to the action of a strong heat. The metallic titanium will be found in a blackish puffed up substance, possessing a metallic appearance.

* Chenevix's paper in Nicholson's Journal, V. p. 134.

ANALYSIS OF ORES OF TITANIUM.

Let the ore of titanium, reduced as usual to a fine powder, be fused with three times the quantity of potash or its carbonate. The melted mass is then to be dissolved in hot water. A white precipitate gradually separates, which is the white oxid of titanium. This is all that is necessary to be done with that species of ore called *red schorl* (*oxid of titanium*). But when iron and silex are present as is the case with the *menachanite*, the following method of Chenevix may be adopted.

Saturate an alkaline solution obtained as above with muriatic acid. White oxid of titanium will thus become precipitated. Separate the precipitate by filtration; evaporate the solution to dryness in a glass bason, and re-dissolve the residuum in distilled water. The silex which was contained in the ore remains behind. Precipitate the solution by an alkali; add the precipitate to the white oxid obtained at first, and dissolve the whole in sulphuric acid. On adding to this solution phosphoric acid the titanium will be precipitated and the iron left behind.

The ore called *titanite*, which contains lime and no iron, must be fused with double or triple its quantity of potash, then dissolved in muriatic acid, and the silex separated as stated before. The titanium is then to be separated from the muriatic solution by adding ammonia to it; and afterwards from the lime by a solution of carbonate of potash.

URANIUM.

PART XL.

NATURAL HISTORY OF URANIUM.

THIS metal was discovered by Klaproth in the year 1789. It exists combined with sulphur and a portion of iron, lead, and silex, in the mineral termed *Pechblende*, or *oxid of uranium*. Combined with carbonic acid it forms the *chalcolite*, or *green mica*: and mixt with oxid of iron, it constitutes the *uranitic ochre*. It is always found in the state of an oxid with a greater or smaller portion of iron or mineralized with sulphur and copper. The ores of uranium are of a blackish colour, inclining to a dark iron grey, and of a moderate splendor; they are of a close texture, and when broken present a somewhat uneven, and in the smallest particles a conchoidal surface. They are found in the mines of Saxony.

PROPERTIES OF URANIUM.

Uranium exhibits a mass of small metallic globules, agglutinated together. Its colour is a deep grey on the outside, in the inside it is a pale brown. It is very porous, and is so soft

that it may be scraped with a knife. It has but little lustre. Its specific gravity is 6.440. It is more difficult to be fused than even manganese. When intensely heated with phosphate of soda and ammonia, or glacial phosphoric acid, it fuses with them into a grass-green glass. With soda or borax it melts only into a grey, opaque, scoriaceous bead. It is soluble in sulphuric, nitric, and muriatic acids. It combines with sulphur and phosphorus, and alloys with mercury. It has not yet been combined with other combustible bodies. It decomposes the nitric acid and becomes converted into a yellow oxid. The action of uranium alone upon water, &c. is still unknown, probably on account of its extreme scarcity.

METHOD OF OBTAINING URANIUM.

In order to obtain uranium, the *pechblende* is first freed from sulphur by heat, and cleared from the adhering impurities as carefully as possible. It is then digested in nitric acid; the metallic matter that it contains is thus completely dissolved, while part of the sulphur remains undissolved, and part of it is dissipated under the form of sulphurated hydrogen gas. The solution is then precipitated by a carbonated alkali. The precipitate has a lemon-yellow colour when it is pure. This yellow carbonate is made into a paste with oil and exposed to a violent heat, bedded in a crucible containing and lined with charcoal.

Klaproth obtained a metallic globule 28 grains in weight, by forming a ball of 50 grains of the yellow carbonate with a little wax, and by exposing this ball in a crucible lined with charcoal to a heat equal to 170° of Wedgwood's pyrometer.

Richter obtained in a single experiment 100 grains of this metal which seemed to be free from all admixture.

ANALYSIS OF ORES OF URANIUM.

These ores may be treated with nitric acid. In order to analyze the *black ore of uranium* or *pechblende*, let one part of the ore reduced to powder be digested in four or five of diluted nitric acid. Repeat this process two or three times. The undissolved residue is a mixture of the silex, sulphur, and iron, which was contained in the ore. To get rid of a small quantity of iron, which generally is taken up by the acid, immerse a polished plate of zinc in the solution. The iron will thus become precipitated. On evaporating the solution a precipitate will ensue which is nitrate of lead. The solution must then be filtered, and a solution of potash added to it, to throw down the zinc and uranium. The precipitate obtained by means of this agent must be transferred into a phial containing liquid ammonia, and suffered to stand for some days. The oxid of zinc will by this means be dissolved, and the oxid of uranium be left behind. It must therefore be separated on a filter, washed and dissolved in diluted sulphuric acid, and then evaporated slowly; it will yield crystals of a lemon-yellow colour.

The *yellow oxid of titanium*, or *uranitic ochre*, may be treated in a similar manner with nitric acid. The uranium will be dissolved in the acid, and the iron left behind.

Green mica, or *chalcolite*, may be analyzed by first dissolving it in nitric acid, and then adding to the solution, liquid ammonia in excess. The oxid of titanium will become precipitated, and the copper which was contained in the ore remain dissolved in the solution.

COBALT.

PART XLI.

SECT. I.

NATURAL HISTORY OF COBALT.

COBALT has never yet been found pure in nature. We meet with it almost always either in the state of an oxid; alloyed with other metals in the form of a sulphuret; or combined with an acid.

Cobalt in the state of an oxid forms the *black cobalt ore*. This ore is found in Germany, either in powder of a black or grey colour, or in compact masses. In the last form it exhibits at its fracture, rose-coloured spots. There are several varieties of this ore.

Cobalt alloyed with other metals forms the *dull white cobalt ore*. In this ore, which occurs either amorphous or crystallized, cobalt is united to iron and arsenic. The colour of this ore when fresh broken is white or blueish-grey, sometimes with a shade of red. It has a metallic lustre. Its texture is compact. Cobalt united to sulphur forms the *white cobalt ore*. It is met with in masses or crystallized in cubes, dodecahedra, and octa-

hedra. Its colour is a tin-white, sometimes reddish-yellow. Cobalt combined with arsenic acid forms the *red cobalt ore*, arseniate of cobalt. It is found in masses of various shapes. Its colour is red, inclining to orange.

PROPERTIES OF COBALT.

Cobalt when in a pure state is of a steel-grey colour, with a tinge of red, and a fine close grain. It has a granulated fracture, and is easily broken and pulverized. Its specific weight is between 7.700 and 7.811. It requires a very intense heat for its fusion, nearly equal to that necessary to melt cast-iron. When heated in contact with the air it oxidates before fusion. Phosphorus renders it very fusible, and converts it into a phosphuret. It unites to sulphur with difficulty, but very well with the alkaline sulphurets by fusion. When alloyed with metals it renders them granulated, rigid and brittle. It is attacked by the greater number of the acids and unites with the boracic acid. Its solutions in different acids become green when heated, and from this property it is used as an ink, which when written with on paper is invisible, but becomes visible when gently heated, and disappears when cold. It takes fire in oxygenated muriatic acid gas. It colours glass of a fine blue. It unites with platina, gold, iron, nickel, copper, and arsenic, by fusion; but silver, lead, bismuth, and mercury, refuse to unite with it in the dry way. In its purest state it is not only obedient to the magnet but if we may trust to the accuracy of some experiments made by Kohl and Wenzel, it may even receive a magnetical attractive power*.

Nitrate of potash oxidates cobalt readily. It detonates by the blow of a hammer when mixed with oxygenated muriate of potash. It produces fine colours in porcelain, enamels, artificial gems, &c.

* Crell's Neue Endeck, vol. VII. p. 39.

METHOD OF OBTAINING COBALT.

The process made use of by chemists for obtaining cobalt is to torrify the cobalt ore in an open fire, in order to separate it from the arsenic or sulphur. The cobalt is then obtained in the state of a black oxid more or less dark. This oxid must be mixed with three parts of black flux, and one of decrepitated muriate of soda; some add also half a part of resin. The whole is put into a crucible of such a capacity that at least one-third of it may remain empty, and placed in a furnace exposed to a gentle heat until the resin ceases to burn; the fire must then be raised gradually, in order to bring the crucible to a white heat, and in that state it must be kept until the matters are completely fused. It is then suffered to cool, and having broken the crucible, the cobalt must be separated from the scoriae, which are of a blue colour.

REMARK...It is impossible to obtain cobalt in this way in a state of considerable purity. It always is contaminated with iron.

In order to get rid of this, the cobalt previously oxidated is to be dissolved in nitric acid. The solution must then be evaporated to dryness and the remainder exposed for some time to a red-heat, whereby the nitrated iron becomes decomposed: or the solution of cobalt in nitric acid may be precipitated by pure potash. The precipitate after being washed is dissolved in nitric acid. This solution must be evaporated to dryness, and re-dissolved in as little distilled water as possible, and then precipitated by liquid ammonia. More ammonia is then to be added in order to re-dissolve the precipitate. This ammoniacal solution must be evaporated to dryness, and then mixt with two parts of black flux into a paste with a sufficient quantity of oil, and exposed to a white heat in a forge for at least two hours. A button will thus be obtained which is pure cobalt.

SECT. II.

EXPERIMENTAL PROOFS
OF
THE PROPERTIES OF COBALT.

EXPERIMENT I.

Cobalt combines with Phosphorus.

(Phosphuret of cobalt.)

THIS may be accomplished by bringing the metal to a red heat in a crucible, and gradually adding phosphorus in small pieces. The compound is whitish and brittle. When exposed to the air it loses its metallic lustre. It is much more fusible than the pure metal. The phosphorus may be separated from it by heat, leaving the metal behind oxidated. -

EXPERIMENT II.

Cobalt decomposes nitric acid by the assistance of heat with great rapidity.

(Nitrate of cobalt.)

Put pounded cobalt into a Florence flask, and pour over it five or six times its weight of nitric acid; place the flask over a lamp, and heat it, till the metal is dissolved; leave the solution at rest, and then decant it. When the solution is at the point of satura-

tion, it has a brown rose-colour, or a bright green. Evaporate the solution in a glass bason till it is reduced one-half; on cooling, it will form crystals in small needles called nitrate of cobalt.

EXPERIMENT III.

Cobalt is soluble in nitro-muriatic acid.

(Muriate of cobalt, or green sympathetic ink.)

Put into a matrass one part of cobalt and four of nitric acid. Digest the mixture on a sand-bath for three or four hours, or until the solution be almost completed; then add muriate of soda equal in quantity to the cobalt employed, and four times as much water as nitric acid; filter the liquor through paper, and nitromuriate of cobalt, or more properly muriate of cobalt, will be obtained.

If letters be traced on clean paper with this solution, they will be invisible; but by exposing the paper to a gentle heat, they will appear of a beautiful green; this colour will disappear as the paper cools, and may be made to appear and disappear successively.

EXPERIMENT IV.

Cobalt combines with acetic acid when in the state of an oxid.

(Acetite of cobalt, or blue sympathetic ink.)

Though acetic acid does not act on cobalt in its metallic state, its oxid is dissolved by it with moderate facility when assisted by heat. The solution of acetite of cobalt is rose-red; it yields a blue sympathetic ink, and is best prepared in the following manner:

Take one ounce of cobalt reduced to powder, put it into a Florence flask and pour over it two ounces of pure nitric acid. Expose the mixture to a gentle heat, and when the cobalt is dissolved, add, by small quantities, a solution of potash, until no more precipitate ensues. Let this precipitate subside, decant the super-natant fluid, and wash the residuum repeatedly in distilled water until it passes tasteless. Then dissolve it in a sufficient quantity of pure distilled vinegar, by the assistance of a gentle heat, taking care to have a saturated solution, which will be known by part of the precipitate remaining undissolved after the vinegar has been digested on it for some time. This fluid is a solution of pure oxid of cobalt in acetic acid, and forms a beautiful blue sympathetic ink, by the addition of about one-eighth part of muriate of soda. This ink, like that made with the nitro-muriatic acid is not visible without heat, and disappears when the paper grows cold.

REMARK...The cause of this singular change of the solutions of cobalt has not hitherto been explained in a satisfactory manner. It takes place equally in close vessels, so that it can scarcely be ascribed to the action of the air or of moisture. At present it is supposed, (but without any direct proof) to be owing to the partial de-oxidation of the oxid of cobalt by heat, and its re-absorption of oxygen when cold.

These phenomena arrested particularly the attention of former chemists, and accordingly to their fanciful way they gave them the name of *sympathetic inks*; an appellation appropriated to all liquids, the characters of which are colourless and invisible when written on paper, but become visible and coloured by undergoing certain processes, and likewise to those which form characters upon paper susceptible of changing their colour by artificial methods.

ANALYSIS OF ORES OF COBALT.

Take one part of the ore reduced to powder, pour over it in a Florence flask three ounces of nitro-muriatic acid, and assist its action by heat till nearly the whole of the ore is dissolved. Let the mixture stand undisturbed for a few hours, decant the supernatant fluid and filter it gradually. The insoluble residue consists of sulphur and silex. To the before-obtained solution, carbonate of potash dissolved in water must be added as long as a cloudiness appears. When no farther precipitate is produced, filter the whole, wash the precipitate which remains on the filter repeatedly, by pouring distilled water over it and then dry it. The precipitate thus obtained consists of iron, arsenic and cobalt. In order to separate these metals, let it again be dissolved in diluted nitric acid, and decompose this solution by adding liquid ammonia till no further precipitate ensues; collect the precipitate and dissolve it in acetous acid, and suffer this solution to evaporate slowly. By this process the iron gradually becomes separated in the form of a yellow or red powder. The solution must therefore again be filtered. The filtered solution which contains the arsenic and cobalt is now to be mingled with liquid ammonia, till the odour of the latter is predominant. The arsenic will then become separated, and the cobalt remains in solution. By then evaporating the ammoniacal solution, the cobalt will be obtained in the state of an oxid. In order to reduce it to its metallic state, it may be mixed with two or three parts of black flux and ore of borax, and then exposed to a violent heat in a smith's forge, for at least one hour and a half.

NICKEL.

PART XLII.

NATURAL HISTORY OF NICKEL.

IT is to Cronstedt that we are indebted for the discovery of this metal; though the substance from which he extracted it was known in the year 1694. Cronstedt proved it to be a peculiar metal in the year 1751. Nickel is found in nature generally in the metallic state, more rarely in that of an oxid. Its ores have a coppery red colour, generally covered more or less with a greenish grey efflorescence. The most abundant ore is that termed *sulphuret of nickel* or *kupfernickel*, which is a compound of nickel, arsenic, sulphuret of iron, and sometimes cobalt and copper. This ore occurs either massive, or disseminated, but never crystallized; it is of a copper colour, sometimes yellowish, white, or grey. It exists also combined with oxygen, and a little carbonic acid, in what is called *native oxid of nickel*, (*nickel ochre*); it then has an earthy appearance, and is very friable: it is found coating *kupfernickel*, and seems

to originate from the decomposition of this ore. It is found contaminated with iron in the mineral substance called *martial nickel*; this native combination, when fresh broken, has a lamellated texture; when exposed to the air, it soon turns black, and sometimes exhibits thin rhomboidal plates placed irregularly over each other. It is also found united to arsenic, cobalt, and alumine in the ore called *arseniate of nickel*.

PROPERTIES OF NICKEL.

Nickel, when free from heterogeneous substances, is of a pale flesh colour. When fresh broken it has a strong lustre. It has a fine grained compact texture, and can be a little flattened by hammering, similar to cast iron. It leaves a trace when rubbed upon the polished surface of a hard stone. Its specific gravity is 7.380. It requires a very intense heat for fusion. When exposed for a long time to a humid atmosphere, its surface becomes gradually covered with an oxid of a greenish hue; this takes place likewise, and more rapidly, when heated in contact with air. When fused with borax it produces a glass of a hyacinth colour. It unites with phosphorus by fusion, and forms with it a phosphuret which is very fusible, white, and in brilliant needles. With sulphur it forms by fusion, a hard yellow mass, with small brilliant facets. Sulphuric acid, assisted by heat, dissolves it. Nitric acid acts on it more readily. Muriatic acid, when heated on it, likewise dissolves part of it. Boracic and phosphoric acids seem to have little or no action on nickel. It readily unites with gold, and renders that metal white and brittle. It likewise fuses with platina, silver, and bismuth. It does not alloy with mercury. It is easily oxidated by the nitrate and the super-oxigenated muriate of potash. *It is not magnetic*, nor has it the smallest effect upon the magnetic needle. This has been proved by Mr. Chenevix, who has also shown that the magnetism of common nickel is owing to the iron which so obstinately adheres to it.

For a portion of iron, *so small as not to be detected by the best chemical tests*, when combined with nickel, is capable of communicating magnetic properties to the whole mass as strong as if the whole were composed of steel.

METHOD OF OBTAINING NICKEL.

To obtain nickel, the ore is first roasted, in order to free it from sulphur and arsenic; it then is changed into a greenish oxid. This oxid is mixed with two or three parts of black flux. The mixture is put into a crucible, and, being covered with decrepitated muriate of soda, it is brought to the state of fusion, by the strongest heat of a smith's forge.

When the crucible is broken, there is found at the bottom, under brown, blackish, and sometimes blue scoriae, a button of a yellowish white colour, equal in weight to a tenth, a fifth, and even a half of the ore employed. This metal, however, is still far from being pure.

In order to purify it, the button obtained is again broken into small pieces, strongly heated, and then digested with its own weight of concentrated sulphuric acid, and distilled to dryness. The dry mass is dissolved in water and filtered. This solution, in general, deposits crystals of arsenic, and finally affords dark green crystals of sulphate of nickel. This sulphate is re-dissolved in water, and decomposed by carbonate of potash. The precipitate is dissolved in liquid ammonia; the blue solution leaves a residuum which is filtered off, and the filtered solution saturated with nitric acid. The nickel is then precipitated in the form of a greyish green powder, by carbonate of potash. From this oxid the metallic nickel is obtainable by exposing it to heat, when made into a mass with oil and a little charcoal powder.

The nickel obtained in this manner was, until lately, considered as perfectly pure. It possesses, however, magnetic properties. It is therefore contaminated with iron,

In order to obtain this metal in a state of absolute purity, the following method of Chenevix must be had recourse to :

Take the native sulphuret of nickel, reduce it to powder, and roast it in contact with charcoal powder over a gentle fire. When no more fumes arise, pour then nitric acid over it, and dissolve it by heat in a Florence flask. Decant the solution, filter it through bibulous paper, and evaporate it to dryness in a glass bason. Dissolve the nitrate of nickel in a sufficient quantity of distilled water, and decompose it by the addition of the strongest liquid ammonia, taking care to add it in excess. The oxid of nickel and cobalt will thus be re-dissolved ; then let the solution stand undisturbed till a precipitate again ensues. The solution must then be evaporated ; it becomes blue during this process, by the precipitation of the cobalt, which should be separated, and the evaporation be then continued to dryness : the residue will be pure oxid of nickel.

In order to reduce this oxid to the metallic state, let it be made into a paste with oil, mix it with about three parts of black flux, and put it into a crucible, covering it with borax and muriate of soda, and heat the crucible violently for an hour and a half in a forge, a button will then be obtained, which is *pure nickel*.

ANALYSIS OF ORES OF NICKEL.

The ore called kupfernickel may be analyzed in the following manner : Let any quantity of the ore be reduced to a fine powder, digest and extract it with nitric acid, as long as this fluid will take up any of the ore. Then transfer the whole on a filter, and wash the residuum by pouring water over it repeatedly. This insoluble residue consists for the most part of sulphur ; all the other substances which were contained

in the ore, are held in solution by the acid. In order to separate them, dilute the solution with water, a turbidness will ensue, and a white precipitate will gradually fall to the bottom. This is the arsenic which was contained in the ore; it may be collected on a filter. A solution of potash must then be added in excess, and the precipitate boiled for a few minutes. The arsenic and sulphur, part of which remained still in the solution, will thus become completely separated. The precipitate must then be dissolved in acetic acid. On adding to this solution, liquid ammonia, in considerable excess, the iron becomes precipitated, and the cobalt and nickel are retained in the fluid. On evaporating this solution, the cobalt becomes precipitated, which must be separated, and on continuing the evaporation to dryness, the nickel which was contained in the ore is obtained.

The ore called *arseniate of nickel*, requires a treatment a little different from this. One part of the powdered ore must first be boiled with three of potash, in six parts of water, for at least an hour. The residuum must be washed, and then analyzed in the manner stated before.

MANGANESE.

PART XLIII.

SECT. I.

NATURAL HISTORY OF MANGANESE.

THIS metallic substance seems, after iron, to be the most frequently diffused metal through the earth, its ores are very common. As a peculiar metal, it was first noticed by Gahn and Scheele, in the years 1774 and 1777. It is always found in the state of an oxid, varying in the degree of oxidation. La Peyrouse affirmed that he had found manganese in a metallic state; but there was probably some mistake in his observation. They are distinguished into *grey oxid of manganese*, *black oxid of manganese*, *reddish white oxid of manganese*, and *carbonate of manganese*. All these combinations have an earthy texture; they are very ponderous; they occur both amorphous and crystallized; and generally contain a large quantity of iron. Their colour is black, blackish-brown, or grey, seldom white. They soil the fingers like soot. They are sometimes crystallized in prisms, tetrahedral, rhomboidal, or striated.

PROPERTIES OF MANGANESE.

Manganese is of a whitish grey colour. Its fracture is granulated, irregular, and uneven. It is of a metallic brilliancy, which it, however, soon loses in the air. Its specific gravity is about 6.850. It is very hard, and extremely brittle. It is one of the most refractory metals, and most difficult to fuse, requiring at least 160° of Wedgwood's pyrometer. Its oxidability is so rapid, that exposure to the air is sufficient to render it red, brown, black, and friable, in a very short time; it can, therefore, only be kept under water, oil, or ardent spirit. It is the most combustible of all the metals. It decomposes water by heat very rapidly, as well as the greater part of the metallic oxids. It decomposes sulphuric acid. It is soluble in nitric acid. It is fusible with earths, and colours them brown, violet, or red, according to its state of oxidation. It discolours glasses tinged by iron. It does not appear to unite with sulphur. It combines with phosphorus. It unites with gold, silver, and copper, and renders them brittle. It unites to arsenic in close vessels, but does not enter into union with mercury. It forms three differently coloured oxids by combining with different portions of oxygen.

METHOD OF OBTAINING MANGANESE.

This metal is obtained by mixing the black oxid, finely powdered, with pitch; making it into a ball, and putting this into a crucible, with powdered charcoal, $\frac{1}{10}$ of an inch thick at the sides, and $\frac{1}{4}$ of an inch deep at the bottom. The empty space is then to be filled with powdered charcoal; a cover is to be luted on; and the crucible exposed, for an hour, to the strongest heat that can be raised. Or, digest the black oxid of manganese repeatedly, with the addition of $\frac{1}{16}$ of sugar, in nitric acid; dilute the mixture with three times its bulk of

water, filter it, and decompose it by the addition of potash; collect the precipitate, form it into a paste with oil, and put it into a crucible, well lined with charcoal. Expose the crucible for at least two hours to the strongest heat of a forge.

Manganese may also be obtained in the following manner :

Prepare a saturated solution of sulphate of manganese, bring it to a boiling heat, and add to it, gradually, a solution of tartrate of potash, until no further precipitate ensues; then filter the solution, and wash the precipitate in water, and when dry, make it into a paste with oil, and proceed as before.

RATIONALE...The sulphuric acid unites to the potash, and forms sulphate of potash, and the tartareous acid joins to the manganese, and forms a tartrate of manganese, which is decomposable by heat.

SECT. II.

EXPERIMENTAL PROOFS

OF

THE PROPERTIES OF MANGANESE.

EXPERIMENT I.

Manganese becomes oxidated at the common temperature of the atmosphere.

IF pure manganese be reduced to small pieces, and exposed to the air, it tarnishes and assumes a lilac-colour, which soon changes to brown and black. The metal then crumbles into a violet-coloured powder, which changes blacker as the oxidation proceeds, and at last becomes the black oxid of manganese. The oxidation is greatly accelerated by the assistance of heat.

EXPERIMENT II.

Formation of the white, or imperfect, oxid of manganese.

Take the residuum left in the retort after the disengagement of oxygenated muriatic acid gas, (page 334) dilute it with distilled water, and filter it. Then decompose it by gradually adding a solution of potash, wash the precipitate, and dry it. This is the white oxid of manganese.

EXPERIMENT III.

The oxid of manganese is soluble in sulphuric acid.

(Sulphate of manganese.)

Let six parts of concentrated sulphuric acid be poured upon one of pulverized black oxid of manganese, and the mixture heated to redness in a glass retort. A vast quantity of oxygen gas will be disengaged, and the residuum will be a hard white mass, which must be powdered and boiled in water. The fluid, when filtered, affords, on adding a little sugar, a colourless solution, which, by evaporation, yields large, transparent, quadrangular crystals, called *sulphate of manganese*.

REMARK. If the coloured solution of sulphate of manganese be exposed to the rays of the sun, it loses its colour, and regains it when removed into darkness.

RATIONALE. This depends on the de-oxidation of the metal by vivid light.

EXPERIMENT IV.

Manganese combines with phosphorus.

(Phosphuret of Manganese.)

Manganese may be united to phosphorus by melting equal parts of this metal, and glacial acid of phosphorus, in a crucible with one sixth part of charcoal powder.

Or, by dropping phosphorus upon red-hot manganese.

The phosphuret of manganese obtained in either of these processes is white, brittle, granulated, and of a metallic lustre. It is more fusible than manganese, and unalterable by exposure to the air. When heated, the phosphorus burns, and the manganese becomes oxidated.

EXPERIMENT V.

Alcalies unite with the perfect oxid of manganese in the dry way.

These compounds possess the singular property of changing colour when dissolved in water: for instance, let one part of black oxid of manganese, reduced to powder, and three parts of nitrate of potash, be exposed to ignition in a crucible, until the mixture fuses; when the mass assumes a dry earthy appearance it is partly soluble in water. If a small portion of this powder be put into a glass, containing spring water, the fluid becomes green, then violet, next reddish, and at last totally colourless. This property, which has acquired to the compound, the name of *mineral cameleon* is destroyed by a very small quantity of sulphuret of potash.

RATIONALE. The nitrate of potash is decomposed, and the black oxid of manganese is brought to the state of a more imperfect oxid by the ignition: it then becomes partly soluble in the potash. This solution would appear blue; but as some portion of oxid of iron is always contained in the black oxid of manganese, its colour is changed to green by the yellow tint of the oxidized iron. This oxid gradually subsides, and the blue colour appears. The oxid of manganese now attracts more oxygen from the air, and assumes a reddish-brown tinge, which increases more and more, and at last becomes black. It is then precipitated, and the solution becomes limpid.

ANALYSIS OF ORES OF MANGANESE.

Ores of manganese always contain a variety of different earths, it is therefore advantageous to free them from these admixtures, by digesting them for some hours, in diluted nitric acid, which has no effect upon the oxid of manganese. This being done, let one part of the ore be digested in six or eight of concentrated muriatic acid, and assist the action by a gentle heat. Repeat this operation, with half this quantity of acid, until no further solution takes place, which may be known by holding a piece of litmus paper over the fumes which arise from the evaporating vessel. If the blue colour of the litmus paper becomes reddened, this operation is at an end, but if its colour becomes discharged, the operation must be continued. The whole is then to be left undisturbed, (the insoluble part which remains consists mostly of silex,) and afterwards filtered. The muriatic solution must then be decomposed by letting fall into it a solution of carbonate of soda. A copious precipitate will instantly take place, which is of a white colour, but it soon becomes grey when left exposed to air; or black, when heated in a crucible. This is the oxid of manganese contained in the ore.

BISMUTH.

PART XLIV.

SECT. I.

NATURAL HISTORY OF BISMUTH.

BISMUTH is found in the earth in very few different states, more generally native or in the metallic state. *Native bismuth* is met with in solid masses, and also in small particles dispersed in and frequently deposited on different stones; at Schreeberg in Saxony, Sweden, &c. Sometimes it is crystallized in four-sided tables, or indistinct cubes. It exists combined with oxygen in the *oxid of bismuth*, (*bismuth ochre*) found in small particles, dispersed, of a bluish or yellowish-grey colour, needle-shaped and capillary; sometimes laminated forming small cells. It is also though more seldom united to sulphur and iron in the form of a sulphuret in the *martial sulphurated bismuth ore*. This ore has a yellowish-grey appearance, resembling somewhat the martial pyrites. And, it is sometimes combined with arsenic.

PROPERTIES OF BISMUTH.

Bismuth is of a silver-white colour inclining to red. It soon tarnishes and becomes iridescent. It is brittle and can easily be reduced to small particles. It is soft enough to be cut with a knife. It has a lamellated texture. Its specific gravity is 9.800. It requires less heat for fusion than any other metal, tin excepted, melting by a heat = 460° Fahr. It can be volatilized by heat and escapes in the state of greyish-white vapour. It readily unites with mercury and with sulphur. When fused it exhibits on cooling, cubical figures on the surface. It is soluble in sulphuric, nitric, and muriatic acids. The solution in nitric acid is decomposable by mere dilution with pure water. It inflames in oxygenated muriatic acid gas. It is capable of combining with the greatest number of the metals; and when in certain proportions, promotes their fusibility remarkably, (page 46). It speedily becomes black by sulphurated hydrogen gas.

METHOD OF OBTAINING BISMUTH.

To obtain bismuth from its ore nothing more is necessary than to fuse the ore with an eighth part of flux in a well closed vessel, the metal will thus be obtained. The metal obtained by this process, however, is far from being in a pure state. It forms the bismuth of commerce.

In order to purify it, let it be powdered, and dissolve it in pure nitric acid and precipitate it, by adding water to the solution. Collect the precipitate on a filter, form it into a paste with oil, and rapidly fuse it with black flux in a closed crucible.

SECT. II.

EXPERIMENTAL PROOFS

OF

THE PROPERTIES OF BISMUTH.

EXPERIMENT I.

Nitric acid dissolves bismuth with great rapidity.

PUT some nitric acid into a Florence flask or common phial, and gradually add to it bismuth broken into small pieces till no more dissolves, then filter the solution. This solution, when evaporated and suffered to crystallize slowly, furnishes a white and exceedingly brilliant salt, which is *nitrate of bismuth*.

It is remarkable that if this metallic salt be dissolved in pure water, it renders it white and milky, which is a criterion to distinguish this from other metals. The precipitate which is thus formed is called *white oxid of bismuth*, and is sold by perfumers under the name of *pearl white*.

EXPERIMENT II.

Preparation of white oxid of bismuth.

Dissolve bismuth in pure nitric acid, diluted with an equal quantity of water. Let the solution stand undisturbed, till it be-

comes perfectly transparent, then add a large quantity of distilled water; a precipitate will instantly be formed. When this has subsided decant the super-natant fluid, and wash the white powder repeatedly in distilled water till it passes tasteless, then suffer it to dry spontaneously in the dark, and keep it in a glass bottle.

REMARK...This oxid is used as a cosmetic for whitening the skin, but it is attended with this inconvenience, that it becomes *black* by coming into contact with fetid substances, &c. The eating of boiled eggs is capable of producing this effect. It is thought, and perhaps with reason, that this paint gradually impairs the skin. The liberal use of *any* paint for the skin seems likely to do this, but have we not reason to suspect, from the deleterious effects of this metal on the animal economy, that the liberal use of the oxid of this metal may be attended with effects similar to those which the oxids of lead are known to produce?

EXPERIMENT III.

Combination of bismuth with phosphorus.

Fuse a little bismuth in a crucible, and let fall upon it gradually small pieces of phosphorus. On removing the crucible from the fire, the phosphuret of bismuth will be found adhering strongly to the crucible.

Sulphuret of bismuth may easily be obtained by melting sulphur and bismuth together.

The union of bismuth with metals is not attended with any difficulty.

EXPERIMENT IV.

Oxid of bismuth decomposes muriate of ammonia by heat.

Mix together one part of oxid of bismuth and two of muriate of ammonia, put the mixture into a glass retort, furnished with

a receiver containing a little water, and proceed to distillation: ammonia will pass over and be absorbed by the water in the receiver, and a little oxid of bismuth, mixed with undecomposed muriate of ammonia, will rise and attach itself to the neck of the retort. The remainder, in the retort, is a combination of the metallic oxid with muriatic acid, called *muriate of bismuth*.

ANALYSIS OF ORES OF BISMUTH.

Ores of bismuth and bismuth ochre are very easily examined. The ore called native bismuth may be analyzed by treating it repeatedly with nitric acid assisted by heat. On adding water to the clear solution the bismuth becomes precipitated in the form of a white powder. If the whole should not be precipitated at first, the solution should be concentrated by evaporation, then a second affusion of water will precipitate the remainder. This precipitate formed into a paste with a few drops of oil, and rapidly fused with black flux, gives a button of bismuth.

The rest of the ores of bismuth may be analyzed in a similar manner. The sulphur which they contain will not be acted upon by the nitric acid, it will therefore be left behind and may be separated by filtration.

ANTIMONY.

PART XLV.

SECT. I.

NATURAL HISTORY OF ANTIMONY.

ANTIMONY is found *native*, but very rarely; it has, in that state, a metallic lustre, and is found in masses of different shapes; its colour is white, between those of tin and silver. It generally contains a small portion of arsenic. It is likewise met with in the state of an oxid, *antimonial ochre*. The most abundant ore of it is that in which it is combined with sulphur, *the grey ore of antimony*, or *sulphuret of antimony*. The colour of this ore is bluish, or steel-grey, of a metallic lustre, and often extremely beautifully variegated. Its texture is either compact, foliated, or striated. The striated is found both crystallized, massive, and disseminated; there are many varieties of this ore.

PROPERTIES OF ANTIMONY.

Antimony is of a greyish white, having a slight bluish shade, and very brilliant. Its texture is lamellated, and exhibits plates crossing each other in every direction. Its surface is covered with herbarizations and foliage. Its specific gravity is 6.702. It is sufficiently hard to scratch all the soft metals. It is very brittle, easily broken, and pulverizable. It fuses at 810° Fahr. It can be volatilized, and burns by a strong heat. When perfectly fused, and suffered to cool gradually, it crystallizes in octahedra. It unites with sulphur and phosphorus. It decomposes water strongly. It is soluble in alkaline sulphurets. Sulphuric acid, boiled upon antimony, is feebly decomposed. Nitric acid dissolves it in the cold. Muriatic acid scarcely acts upon it. The oxygenated muriatic acid gas inflames it, and the liquid acid dissolves it with facility. Arsenic acid dissolves it by heat with difficulty. It unites, by fusion, with gold, and renders it pale and brittle. Platina, silver, lead, bismuth, nickel, copper, arsenic, iron, cobalt, tin, and zinc, unite with antimony by fusion, and form with it compounds, more or less brittle. Mercury does not alloy with it easily. We are little acquainted with the action of alcalies upon it. Nitrate of potash is decomposed by it. It fulminates by percussion with oxygenated muriate of potash.

METHODS OF OBTAINING ANTIMONY.

1. To obtain antimony, heat 32 parts of filings of iron to redness, and project on them, by degrees, 100 parts of antimony; when the whole is in fusion, throw on it, by degrees, 20 parts of nitrate of potash, and after a few minutes quiet fusion, pour it into an iron melting cone, previously heated and greased.
2. It may also be obtained by melting eight parts of the ore mixed with six of nitrate of potash, and three of acidulous tartrate of potash, gradually projected into a red-hot crucible, and fused.

To obtain perfectly pure antimony, Margraaf melted some pounds of the sulphurated ore in a luted crucible, and thus scorified any metals it might contain. Of the antimony thus purified, which lay at the bottom, he took sixteen ounces, which he oxidated cautiously, first with a slow, and afterwards with a strong heat, until it ceased to smell of sulphur, and acquired a greyish white colour. Of this grey powder he took four ounces, mixed them with six drachms of acidulous tartrate of potash, and three of charcoal, and kept them in fusion in a well covered and luted crucible, for one hour, and thus obtained a metallic button that weighed one ounce, seven drachms, and twenty grains.

The metal, thus obtained, he mixed with half its weight of desiccated carbonate of soda, and covered the mixture with the same quantity of the carbonate. He then melted it in a wet covered and luted crucible, in a very strong heat, for half an hour, and thus obtained a button which weighed one ounce, six drachms, and seven grains, much whiter and more beautiful than the former. This he again treated with one and a half ounce of carbonate of soda, and obtained a button, weighing one ounce, five drachms, and six grains. This button was still purer than the foregoing. Repeating these fusions with equal weights of carbonate of soda three times more, and an hour and a half each time, he at last obtained a button so pure as to amalgamate with mercury with ease, very hard, and in some degree malleable; the scoriae formed in the last fusion were transparent, which indicated that they contained no sulphur, and hence it is the obstinate adherence of the sulphur that renders the purification of this metal so difficult,

SECT. II.

EXPERIMENTAL PROOFS

OF

THE PROPERTIES OF ANTIMONY.

EXPERIMENT I.

Antimony combines with different portions of oxygen.

WHEN antimony is beaten to powder, and exposed for some time to a dull red heat, in an open vessel, it absorbs oxygen, and is converted into a grey powder. This is called *grey oxid of antimony*.

When the metal is exposed to a higher temperature the product is *white oxid of antimony*. For instance,

Place a triangular crucible in a furnace, not vertically, but in the manner of a muffle, with its bottom somewhat inclined. Its mouth must project a little without the door, through which it is introduced into the furnace, and it may be luted in that position. Put some metallic antimony into it, and place over its mouth another crucible, to receive the oxid. Bring the metal to a white heat, and remove the upper crucible every half hour,

putting another in its place; these will be filled with a white silvery looking substance, which must be detached with a feather. This is *white oxid of antimony*.

If this or the former oxid be exposed to a more violent heat, it fuses into a transparent vitreous mass, which varies in colour from a faint yellow to a dark red hyacinth, or orange colour. This is called *vitreous oxid of antimony*, or *glass of antimony*.

To ascertain if the fusion be perfect, immerse an iron rod into it, and, when taken out, examine the substance which adheres to it: if it be transparent, and can be easily drawn into a fine thread like common glass, the fusion is compleat; then remove the crucible from the fire and pour out its contents on a heated plate of copper.

All these products are imperfect oxids of antimony.

When nitrate of potash is decomposed by antimony the result is a combination, known under the name of diaphoretic antimony, which is a more perfect oxid than the former.

EXPERIMENT II.

Preparation of perfect oxid of antimony.

Let equal parts of nitrate of potash, and sulphuret of antimony, be intimately blended together, project the mixture, by small quantities, into a crucible brought to a red-heat; on every addition of the mixture a detonation will take place. When the whole has been thrown into the crucible, expose it to a heat sufficient to bring the matter into a state of fusion: then take the crucible from the fire, and having suffered it to cool, separate the scoriae from the oxid of antimony, which will be found in the form of a brown opake mass.

REMARKS. Native, or crude antimony, as it is called, and which is obtained by the smelting of different antimonial ores, has the same nature and properties as the factitious sulphuret of antimony.

When this substance is prepared in pharmacy, the native sulphuret is generally used. In this case a larger quantity of nitrate of potash is required to be added, as for example, three parts to one of the mineral, in order that all the sulphur, as well as the metal to which it is united, may be completely oxidated. The reason why the ore is preferred in this process is, that the sulphur renders the detonation more rapid, and singularly facilitates the combination of the antimony.

If the mixture is not brought to fusion, only vitreous scoriae will be obtained: the nitrate of potash, in this case, is not sufficient to change all the sulphur of the native sulphuret, into sulphuric acid to oxidate the metal completely. This matter, when reduced to powder, and washed in water, forms *crocus metallorum*, which is only a semi-vitreous oxid of antimony, pulverized and separated from the saline matters which arise from the detonation of the nitrate of potash.

EXPERIMENT III.

Combination of antimony with phosphorus.

(Phosphuret of antimony.)

To obtain this substance, mix together equal parts of glacial acid of phosphorus and antimony, and one-eighth part of powdered charcoal; fuse the whole in a crucible, the result will be a white brittle metallic substance, having a lamellated fracture when broken, and at the fracture appear a number of small cubic facets. When melted it emits a green flame, and then sublimes in the form of a white powder.

Phosphuret of antimony may also be obtained by projecting phosphorus on red-hot antimony. Care must be taken to remove the crucible from the fire as soon as the last portions of the phosphorus have been added; without this precaution nearly all the phosphorus would be volatilized.

EXPERIMENT IV.

*Combination of antimony with sulphur.**(Sulphuret of antimony.)*

To procure sulphuret of antimony, pulverize equal parts of sulphur and antimony; put the mixture into a crucible, cover it and expose it to a heat sufficient to make the crucible slightly red; when the matters are fused, take the crucible from the fire, suffer it to cool, and the contents will be found to be a brilliant radiated mass of a lead or slate-grey colour.

EXPERIMENT V.

Preparations of hydrogenated hidro-sulphuret of antimony.

Into a boiling ley of pure potash dissolved in about three or four times its weight of water, throw sulphuret of antimony equal to a sixteenth of the alcali employed. Stir the mixture well, and after it has boiled a little, filter it. On cooling, this liquor will deposit an abundant precipitate, which must be washed, first with cold, and afterwards with boiling water, until it becomes insipid: when dry, pulverize it and sift it through a silk sieve. Or,

Boil ten or twelve parts of pure liquid alcali with two parts of sulphuret of antimony; keep the mixture in a state of ebullition for half an hour, then filter it, and on cooling a precipitate will be obtained. Digest the alcali again over more sulphuret until it is exhausted. Wash and dry the product as before.

To these processes, we shall add that of Deyeux. Chemists and those who prepare medicines of this kind on a large scale, will no doubt see the details he has communicated, with pleasure.

Take carbonate of potash, one part; sulphuret of antimony, pounded small, four parts; river water, filtered, eight parts.

Boil the whole in a very clean iron vessel for a quarter of an hour; then take out a small quantity of the liquor with an iron spoon, and if, as the liquor cools, it becomes turbid, and forms a reddish deposit, it contains kermes in solution. Should the contrary be the case, continue the ebullition till the above phenomena are manifested; then pour the boiling liquor on a filter of paper, placed on a piece of pretty thick cloth: the liquor will pass exceedingly clear; but as it reaches the bottom of the jar placed to receive it, it becomes turbid and deposits an abundant precipitate.

During the filtration of the liquor, carbonate of potash and water, each equal in quantity to that first employed, are to be added to the sulphuret which remains in the iron vessel and boiled as before. This operation is to be repeated four times, and the liquor obtained from each is to be filtered separately.

During the fourth operation, the filtered liquors of the two first will have deposited the kermes they contained. They must be carefully decanted, and the liquors boiled again with the sulphuret of antimony, which has remained in the iron vessel.

The same method must be observed with the liquors of the third and fourth operation, and so repeated until the whole of the kermes has been obtained; but as the water and alcali decrease as the operations are repeated, care must be taken to add, from time to time, a solution of carbonate of potash, observing that the quantity be not too great, otherwise the kermes will remain in solution in the liquor and not be deposited on cooling.

Care must also be taken to renew the paper filters frequently, as their pores speedily become closed. Each time they are changed the matter deposited upon them must be returned into the boiler.

The kermes deposited in the jars during each operation, must be put into a separate vessel, and suffered to remain there till the requisite quantity is obtained; it must then be freed from the alcali with which it is still moistened and dried.

For this purpose, after having carefully decanted the supernatant fluid; wash the precipitate in a large quantity of river-water, which should be filtered and as cold as possible; suffer it to settle and decant it; and repeat the washing until the decanted liquor has no alkaline taste.

The precipitate collected at the bottom of the last water must be thrown on several paper filters, placed either in funnels or over pieces of cloth, in such a manner that the matter on each filter may be about two inches in thickness. As the moisture drains off, the kermes shrink, crack and acquire a consistence. A small quantity of it must be taken from time to time to examine what state it is in, and when, by touching it with a spatula, it begins to divide itself without daubing, put it between two leaves of paper, and having wrapped it in a linen cloth, put it under a press, and then suffer it to dry in a very moderate temperature.

REMARK...This process is indeed longer and more tedious than the former, but it yields a product of a beautiful colour, and whose medicinal effects never vary.

A product of the same nature is that formerly called sulphur of antimony, but now hydrogenated sulphurated oxid of antimony.

EXPERIMENT VI.

Preparation of hydrogenated sulphurated oxid of antimony.

This product may be obtained by letting fall, either nitric, sulphuric, or muriatic acid into the liquor in which the hydrogenated hidro-sulphuret of antimony has been formed, and from which it has been entirely separated by cooling. This liquor becomes again turbid by the addition of the acid, and there is formed in it a second precipitate, which is a reddish-yellow, or orange coloured hydrogenated sulphurated oxid of antimony. If the liquor be filtered and more acid added, another precipitate will ensue, but less coloured.

This oxid is however in general, more expeditiously obtained by boiling two parts of sulphuret of antimony, and three parts of sulphur both reduced to fine powder, with a sufficient quantity of water in an iron pot, filtering the liquor and precipitating it with diluted sulphuric acid. The product obtained contains about 75 parts of sulphur in 100.

RATIONALE...All these processes consist in uniting, in a more or less direct manner, the oxid of antimony with sulphurated hydrogen. It is, as Fourcroy has observed, the uniform effect which is produced by all the alcalies, whether they are employed hot or cold, with sulphuret of antimony; they first oxidate the metal, and form with the sulphur a sulphuret charged with hydrogen; this unites with the oxid of the metal which remains in solution. The alkaline sulphuret precipitated afterwards by an acid, in the form of an orange-coloured powder, is in reality nothing but an oxid of antimony, surcharged with sulphurated hydrogen and sulphur.

The principal difference between this preparation and the former consists in this, that the first contains sulphurated oxid of antimony in addition to the hidro-sulphuret of antimony of the latter. In a word, there is no reason to doubt that it is to the sulphurated hydrogen in the mineral kermes, that this medicine is indebted for the virtues by which it is characterized.

EXPERIMENT VII.

Antimony decomposes oxygenated muriate of mercury.

Mix intimately one part of antimony with two of oxygenated muriate of mercury, and introduce the mixture into a glass retort with a wide aperture, leaving about one-third of it empty. Place the retort on a sand-bath, in a reverberating furnace; adjust to the retort a receiver whose capacity is two-thirds less than that of the retort, and proceed to distillation with a gentle heat. During the first half hour there passes over a clear white liquor,

followed by another which becomes fixed into a white mass in the receiver; this is what is called *oxigenated muriate of antimony*, formerly termed, from its consistence, *butter of antimony*. As this substance often choaks up the neck of the retort, a burning coal must be applied, to melt it, and make it pass into the receiver. The distillation is to be continued till nothing more passes over, after which the vessels are suffered to cool; and the receiver, being unluted, is exposed to a gentle heat, above a chafing dish to liquefy the oxigenated muriate of antimony.

The properties of this compound are the following: It is exceedingly caustic and instantly destroys the organs of the body. It burns vegetable matters. It fuses by a low degree of heat, and becomes fixed on cooling. It readily loses its whiteness. It is alterable by light. It strongly attracts the moisture of the atmosphere, and resolves itself into a thick, and as it were, oleaginous fluid. It crystallizes in very large parallelopipeda. It is very difficult to keep it in a solid state. It has the property also of being partly soluble, in water, and of being decomposed, in a great measure, by that fluid.

When it is thrown into distilled water, a white oxid of antimony is very abundantly precipitated. This powder, when washed several times in a large quantity of boiling water, and then dried, was formerly called *Algaroth's powder*.

RATIONALE...In this operation, the antimony robs the oxigenated muriate of mercury of part of its oxigen, and becomes oxidated; it then unites to most of the acid, with which it forms oxigenated muriate of antimony. If the distillation be continued after the oxigenated muriate of antimony has passed, fluid mercury will be obtained. Oxigen is therefore more strongly attracted by antimony than by mercury.

If sulphuret of antimony be exposed to distillation with oxigenated muriate of mercury; oxigenated muriate of antimony and red sulphuret of mercury (*cinnabar*) will be obtained. Upon this is founded the following process:

EXPERIMENT VIII.

Preparation of cinnabar of antimony.

Pulverize one part of sulphuret of antimony and three of oxygenated muriate of mercury, according to Baumé; but according to Fourcroy, one part of the former to two of the latter, mix these substances and proceed in other respects as in the preceding operation. When the distillation is finished, adapt another receiver to the retort and sublime the residuum with a strong heat. A substance will be obtained in the form of red needles called cinnabar of antimony.

This is the effect of a double affinity. The sulphuret of antimony exchanges its sulphur for the acid given up by the oxygenated muriate of mercury.

The combination of antimony with other metals is not attended with any difficulty.

ANALYSIS OF ORES OF ANTIMONY.

These ores may be analyzed by digesting by heat one part of the ore, reduced to a fine powder, in four parts of nitro-muriatic acid, composed of three or four of muriatic acid, and one of nitric acid. The sulphur contained in the ore will remain behind untouched. On filtering the solution, the antimony must be disengaged by the mere admixture of water, and may be collected on a filter. To reduce it to the metallic state let it be mixed with double its weight of charcoal and fuse it in a crucible. The metal will then be found at the bottom.

As lead and iron are sometimes present in these ores they may be detected by letting fall into the last solution from which the antimony has been separated, a few drops of sulphuric acid; if lead be present a white precipitate will ensue. If iron be present a yellowish-brown precipitate will take place on adding liquid ammonia to the solution.

TELLURIUM.

PART XLVI.

NATURAL HISTORY OF TELLURIUM.

THIS is a new metal discovered by Klaproth, in the year 1797. It is found in three different ores, namely, 1. In the *white gold ore of Fatzebay*, formerly named *aurum paradoxum*, found in the mine called Maria-hilf, in the mountains of Fatzebay, in Transylvania. In this ore Tellurium exists alloyed with gold and iron. Its colour is between tin-white and lead-grey. It is in general found massive. The texture of this ore is granular, and its lustre considerably metallic. 2. In the *graphic gold ore (aurum graphicum)* of Offenbanya, it is alloyed with gold and silver. This ore is composed of flat prismatic crystals, the arrangement of which has some resemblance to Turkish letters, hence the name of the ore. It has a metallic lustre, and a tin-white colour, with a tinge of brass-yellow. 3. It exists also in the ore known under the name of the *yellow foliated gold ore of Nagyag*; alloyed with gold, lead,

silver, copper, and sulphur. This ore is found in plates of different degrees of thickness. Its colour is of a deep lead-grey, passing to iron-black. It has a considerable metallic lustre, and stains the fingers.

PROPERTIES OF TELLURIUM.

The colour of tellurium is white, like that of tin, but inclining to a leaden grey. It has a considerable metallic lustre. Its texture is lamellated, like antimony. It is exceedingly brittle and friable. If it be fused, and suffered to cool gradually, undisturbed, it readily assumes a crystallized surface. Its specific gravity is 6.115. It is one of the most fusible metals, melting as easily as tin. Heated with the blow-pipe, it burns with a brilliant blue flame, greenish at the edges; and is so volatile as to rise totally in grey whitish fumes, emitting a disagreeable odour, approaching to that of radishes. It forms, with sulphur, a grey radiated sulphuret, and alloys very well with mercury. It is soluble in the nitric and nitro-muriatic acids; the latter solution is decomposable by water. It is likewise soluble in boiling concentrated sulphuric acid. The solution acquires a fine red colour, which is lost either by heating it, or by the addition of water.

These are the principal physical properties of this metal.

METHOD OF OBTAINING TELLURIUM.

Tellurium is obtained according to Klaproth, by forming oxid of tellurium into a paste, with a few drops of linseed oil, and then putting it into a small glass retort, or crucible. As the oil becomes decomposed, brilliant and metallic drops are observed on the upper part of the vessel, which increase in number until the oxid is revived.

The process for obtaining oxid of tellurium may be seen in the following

ANALYSIS OF ORES OF TELLURIUM.

Let the white gold ore be gently heated with six parts of muriatic acid; three parts of the nitric being then added, the mixture is boiled, upon which there arises a considerable effervescence, and a complete solution is obtained. The filtered solution must be diluted with as much water as it can bear without becoming turbid, which is a very small quantity, and a solution of potash is then to be added to the liquor, until the white precipitate, which is at first formed, disappears, and nothing remains but a brown flaky sediment, which is the oxid of gold mixed with the oxid of iron contained in the ore. This may be dissolved in nitro-muriatic acid, and the gold be precipitated by a solution of nitrate of mercury, and then the iron by potash. Muriatic acid is then added to the before obtained alkaline solution, in sufficient quantity to saturate the potash. An excess of the acid must be avoided. A white precipitate is thus produced in great abundance. This, when washed, is the oxid of tellurium.

Class III....PARTLY DUCTILE AND OXIDABLE METALS.

MERCURY.

PART XLVII.

SECT. I.

NATURAL HISTORY OF MERCURY.

MERCURY is found in five different states in nature; it is found native, (*native mercury*,) adhering in small globules to the surface of cinnabar ores, or scattered through the crevices, or over the surfaces of different kinds of stones. It is found united to silver, in the ore called *amalgam of silver*, or *native amalgam*. This ore exhibits thin plates, or grains; it sometimes crystallizes in cubes, parallelopipeda, or pyramids. Its colour is of a silver-white, or grey; its lustre is considerably metallic. Combined with sulphur it constitutes *native cinnabar*, or sulphuret of mercury. This ore is the most common. It is frequently found in veins, and sometimes crystallized in tetrahedra, or three-sided pyramids. Its colour is red. Its streak metallic.

Mercury, united either to muriatic, or sulphuric acid, forms the ore called *horn quicksilver*, or corneous mercury. These ores are, in general, semi-transparent, of a grey or white colour, sometimes crystallized, but more frequently in grains. United to oxygen it constitutes the ore called *native oxid of mercury*. Mercurial ores particularly abound in Spain, Hungary, China, and South America.

PROPERTIES OF MERCURY.

Mercury, or quicksilver, is the only one of the metals that remains fluid at the ordinary temperature of the atmosphere, but when its temperature is reduced to -40° Fahr. it assumes a solid form. This is a degree of cold, however, that only occurs in high northern latitudes, and, in our climate, mercury cannot be exhibited in a solid state, but by means of artificial cold. When rendered solid it possesses both ductility and malleability. It crystallizes in octahedra, and contracts strongly during congelation. It is divisible into very small globules. It presents a convex appearance in vessels to which it has little attraction, (page 29), but is concave in those to which it does adhere. It becomes electric and phosphorescent by rubbing upon glass, and by agitation in a vacuum. It is a very good conductor of caloric, of electricity, and of galvanism. The specific gravity of mercury is 13.563. Although fluid, its opacity is equal to that of any other metal, and its surface, when clean, has considerable lustre. Its colour is white, similar to silver. Exposed to the temperature of 600° Fahr. it is volatilized. When agitated in the air, especially in contact with viscous fluids, it becomes converted into a black oxid. At a temperature nearly the same as that at which it boils, it absorbs about 14 or 16 per cent. of oxygen, and then becomes changed into a red crystallizable oxid, which is spontaneously reducible by caloric and light at a higher temperature. The greater number of the acids act upon mercury, or are at least capable of combining with its oxids. It combines with sulphur

by trituration, but more intimately by heat. It is acted on by the alkaline sulphurets. It combines with many of the metals; these compounds are brittle, or soft, when the mercury is in large proportion. There is a slight union between mercury and phosphorus. It does not unite with carbon or the earths.

METHOD OF OBTAINING MERCURY.

Mercury may be obtained pure by decomposing cinnabar, by means of iron filings. For that purpose take two parts of red sulphuret of mercury (cinnabar) reduce it to powder, and mix it with one of iron filings, put the mixture into a stone retort, direct the neck of it into a bottle, or receiver, filled with water, and apply heat. The mercury will then be obtained in a state of purity.

RATIONALE...Sulphuret of mercury consists of sulphur and mercury; if this be heated in contact with iron, the sulphur quits the mercury and unites to the iron, and the mercury becomes disengaged; the residue in the retort is a sulphuret of iron.

SECT. II.

EXPERIMENTAL PROOFS

OF

THE PROPERTIES OF MERCURY.

EXPERIMENT I.

*Mercury is volatilized, or may be converted into vapour
by heat.*

THIS method is employed with advantage for purifying mercury, by separating it from substances more fixed than itself.

For this purpose put mercury into a retort, and adapt to its beak a small bundle of tow, or lint, adjust a matrass containing water to the retort, and proceed to distillation. When the mercury is pure it passes over entirely: if it contains foreign matters, they are left at the bottom of the retort. Sometimes it leaves a little grey powder, which is mercury oxidated by the air contained in the vessels.

EXPERIMENT II.

Mercury combines with sulphur.

Put into a stone mortar one part of mercury, and three of sulphur reduced to a fine powder; triturate them together, and moisten the mixture with a little water until the mercury perfectly disappears; the result will be a black hidro-sulphuret of mercury.

EXPERIMENT III.

Preparation of cinnabar, or red sulphuret of mercury.

This is a more intimate combination of sulphur with mercury than the former, and is prepared in the following manner. Melt in a crucible one part of pounded sulphur, and add to it four of mercury, stir the mixture in order to assist the union of the substances. When they begin to combine, the mixture takes fire spontaneously; quench the flame by covering the crucible, and having suffered the matter to cool, pulverize it in a marble mortar.

Put the powder resulting from it, which is of a violet colour, into a Florence flask, place it on a sand-bath, and proceed to sublimation, by exposing the vessel to a gradually increasing heat till the bottom of the crucible becomes red, and maintain it in that state for some time, suffer the vessel to cool, and having broken it, separate the cinnabar which has sublimed.

Mr. Kirchoff has made us acquainted with another method of obtaining cinnabar, more simple and elegant than the former, which is as follows.

EXPERIMENT IV.

Let 300 grains of mercury, and 68 of sulphur, with a few drops of a solution of potash to moisten them, be triturated in a Wedgwood's, or glass mortar, until it be converted into a black powder. Add to this 160 grains of potash, dissolved in as much water. Heat the vessel containing the ingredients over the flame of a candle, and continue the trituration without interruption during the heating. As the liquid evaporates, add water from time to time, so that the black oxid may be constantly covered, to the depth of an inch. The trituration must be con-

tinued until the mixture begins to change from its original black colour to a brown, which usually happens when a large part of the fluid is evaporated; it then passes very rapidly to a red. No more water is now to be added, but the trituration is to be continued. When the mass has acquired the consistence of a jelly, the colour increases in brightness, with an incredible degree of quickness. The instant it has acquired its utmost beauty, the heat must be withdrawn, otherwise its brilliancy will be impaired, and the red will pass to a brown colour. This red powder is also sulphuret of mercury or cinnabar.

REMARKS...Until lately cinnabar was considered to be a compound of the red oxid of mercury and sulphur, but Mr. Proust has shown that it is composed of about 15 parts of sulphur, and 85 of mercury, and that it differs from the preceding preparation in not containing hidrogen.

Count de Moussin Pouschin has discovered that its passing to a brown colour may be prevented by taking it from the fire as soon as it has acquired a tolerable red colour, and placing it for two or three days in a gentle heat, taking care to add a few drops of water, and to agitate the mixture from time to time. During this exposure the red colour gradually improves, and at last becomes excellent. He discovered also that, when the sulphuret is exposed to a strong heat, it becomes instantly brown, and then passes to a dark violet; when taken from the fire it acquires a beautiful carmine red.

EXPERIMENT V.

Preparation of phosphuret of mercury.

Put into a Florence flask equal parts of red oxid of mercury, and phosphorus; add one part of water, and place the flask on a sand-bath, taking care to shake it frequently, and not to remove it from the bath too early; it will soon become blackish, and in that state the mercury remains united to the phosphorus.

The water becomes sensibly acid from the formation of phosphoric acid.

RATIONALE...In this experiment the oxygen of the oxid of mercury quits that metal to join a portion of the phosphorus, which it converts into phosphoric acid; the mercury, thus deprived of its oxygen, and greatly divided, unites with the remainder of the phosphorus, and forms a peculiar combination, in which phosphorus predominates. The product becomes soft in boiling water, and regains its consistence when the water ceases to be warm.

EXPERIMENT VI.

Mercury decomposes sulphuric acid.

Put into a glass retort two parts of mercury, and three of concentrated sulphuric acid; convey the neck of the retort under a receiver in the pneumatic apparatus, and expose the mixture to heat; a strong effervescence is gradually excited, the surface of the mercury becomes white, and a powder of the same colour is separated, which renders the acid turbid by dispersing itself through it.

In this operation a great deal of sulphureous acid gas is disengaged. (See page 319).

If the heat be continued until no more gas issues from the retort, a white opaque mass will be obtained, which is exceedingly caustic, and attracts the moisture of the atmosphere. This mass is an *oxi-sulphate of mercury*. When water is poured upon it part of the acid is separated, and the salt assumes the form of a yellow powder, formerly called *turpeth mineral*.

The white saline mass is of various natures and properties, according as a greater or less quantity of acid has been used, and according to the length of time the heat has been applied. As will be seen in the following experiment.

EXPERIMENT VII.

Preparation of sulphates of mercury.

Let two parts of mercury be boiled in a retort, with three of concentrated sulphuric acid, interrupt the operation as soon as the mercury has been converted into a white mass. After refrigeration decant the fluid from this mass, and wash it in a little cold distilled water. This saline compound is a *super-sulphate of mercury*.

If this super-sulphate of mercury be repeatedly washed in cold distilled water, until the water which is decanted ceases to red-den litmus paper, there remains behind a white mass, which is a *sulphate of mercury*.

EXPERIMENT VIII.

Mercury is not acted on by muriatic acid alone, but may be combined with it by double affinity.

Let equal parts of dry sulphate of mercury, and dry muriate of soda, be accurately mingled by trituration in a stone mortar; put the mass into a glass retort, and heat it on a sand-bath. A white salt will sublime in the shoulder of the retort, which is commonly called *corrosive sublimate of mercury*.

RATIONALE...In this process the sulphuric acid of the oxid unites to the soda of the common salt, and the muriatic acid of the latter combines with the mercurial oxid, and forms a new compound.

EXPERIMENT IX.

Preparation of mild muriate of mercury.

If four parts of corrosive muriate of mercury be well mingled by trituration with three of fluid mercury, they assume the form

of a grey powder. If this powder be sublimed in a sand-heat, either from an ordinary phial placed in a crucible-bath for small experiments, or from a bolthead in the large way, a white crystalline sublimate is obtained, which must be carefully separated from the unsublimed grey powder and running mercury. The product thus obtained is a combination of a very imperfect oxid of mercury with muriatic acid, called *mild muriate of mercury*, (*calomel, or mercurius dulcis.*)

RATIONALE...Mild muriate of mercury, or calomel, prepared by the above process, is produced in the following manner: The fluid mercury deprives the perfect oxid, which is combined with muriatic acid in the corrosive sublimate, of part of its oxygen; in other words, it is oxidated at the expence of that oxid. Both the perfect oxid, and the mercury, are thus changed into an imperfect mercurial oxid, which the muriatic acid is capable of saturating, notwithstanding the quantity of the oxid has been augmented. The redundant imperfect oxid, and also the redundant fluid mercury, are separated from the mild muriate by its sublimation.

EXPERIMENT X.

Mercury decomposes nitric acid with great rapidity.

When diluted nitric acid is poured upon mercury, a violent action takes place, and nitrous gas is disengaged, the metal is gradually oxidated, and dissolved in that portion of the acid which remains undecomposed. If the solution be evaporated it yields crystals, which are *nitrate of mercury*.

REMARK...When a concentrated acid is made to act upon mercury, or if the action be assisted by heat, the metal combines with a greater portion of oxygen, and a white precipitate falls down, which is an *oxi-nitrate of mercury*.

EXPERIMENT XI.

Preparation of red nitrated oxid of mercury.

For this purpose let the nitrate of mercury obtained in the last experiment be pulverized in a glass mortar, and put into one or more matrasses placed on a sand-bath; the vessels are then to be gradually heated until the contents become of a yellow colour at the surface; suffer them to cool, and the matter they contain will be found in strata of different colours. The lower part is of a bright red colour, and the upper of an orange yellow. The mass, when pulverized, is *red oxid of mercury*.

EXPERIMENT XII.

Mercury readily unites to gold, silver, copper, &c.

This may be evinced by rubbing a little mercury on a gold, silver, or copper coin. Or, the combination may be facilitated by igniting the coin, and in that state conveying it into hot mercury. The mercury may be again expelled by heat.

EXPERIMENT XIII.

Mercury is not oxidated at ordinary temperatures; but when its temperature is raised nearly to that at which it boils, it combines with oxygen.

Put into a flat bottomed matrass with a long narrow neck, as much mercury as is sufficient to cover the bottom of it to the height of a line or two; fuse the neck of the vessel by means of a blow-pipe, draw it out to a fine point, and form it into a capillary tube: instead of breaking the point to afford access to the external air, it is better to pierce the bulb of the matrass at the centre, and adjust to the hole a bent tube immersed in atmospheric air, in such a manner that the air may be renewed

much easier, and enter in greater quantity, which facilitates the operation. Place the apparatus in a sand-bath, expose it to heat till the mercury boils, and maintain the fire at the same degree for several days. The oxid formed at the surface of the mercury is separated by means of a piece of linen cloth which is pressed. The mercury passes through it, while the oxid remains behind; and this operation must be continued till the mercury is completely oxidated.

This substance has been called *mercury precipitated per se*, or red precipitate of mercury without addition: it is a real oxid of mercury or a combination of this metal with oxygen, which it gradually takes from the atmosphere. It contains about 7 per cent. of oxygen.

EXPERIMENT XIV.

Preparation of fulminating mercury.

It has lately been discovered by Mr. Howard, that mercury, and most, if not all of its oxids, may, by treatment with nitric acid and alcohol, be converted into a whitish crystallized powder, possessing all the inflammable properties of gun-powder, as well as many peculiar to itself. It is obtained in the following manner.

One hundred grains (or a greater proportional quantity, not exceeding 500) are to be dissolved, with heat, in a measured ounce and a half of nitric acid. This solution being poured *cold* upon two measured ounces of alcohol, previously introduced into any convenient glass vessel, a moderate heat is to be applied till effervescence is excited. A white fume then begins to undulate on the surface of the liquor, and the powder will be gradually precipitated on the cessation of action and re-action. The precipitate is to be immediately collected on a filter, well washed with distilled water, and cautiously dried in a heat not exceeding that of a water-bath. The immediate washing of the powder is material, because it is liable to the re-action of the nitric acid;

and while any of the acid adheres to it, it is very subject to the action of light. From 100 grains of mercury about 120 or 130 of the powder are obtained.*

This powder, when struck on an anvil with a hammer, explodes with a stunning disagreeable report; and with such force as to indent both the hammer and the anvil. Three or five grains are as much as ought to be used for such experiments.

The shock of an electric battery sent through it produces a very similar effect.

A quantity of it sufficient to discharge a bullet from a gun, with a greater force than an ordinary charge of gun-powder, always bursts the piece.

From a series of well conducted experiments Mr. Howard concludes that this preparation consists of oxid of mercury, oxalic acid, and nitrous etherized gas. Its detonation is owing to the sudden combination of the oxygen with the carbon and hydrogen of these substances, forming aqueous vapour and carbonic acid; and disengaging nitrogen gas; while at the same time so much caloric is suddenly liberated that the elasticity of the gases is not only encreased, but the mercury is instantaneously converted into vapour.

EXPERIMENT XV.

Congelation of mercury.

The freezing of mercury was, until lately, a difficult experiment. We are indebted to Mr. Pepys for an easy method of effecting this. This gentleman, with the assistance of some friends, froze, in the winter of 1799, 56lb. of mercury into a solid and malleable mass. The process was as follows.

* Philosoph. Trans. 1800, p. 214.

The mercury was put into a strong bladder, and well secured at the mouth.

The temperature of the laboratory at the time being $+ 33^{\circ}$. A mixture, consisting of muriate of lime, 2lb. at $+ 33^{\circ}$, and the same weight of snow at $+ 32^{\circ}$. gave a degree of cold $- 42^{\circ}$. The mercury was put as gently as possible into this mixture, (to prevent a rupture of the bladder), by means of a cloth held at the four corners. When the cold mixture had robbed the mercury of so much of its heat, as to have its own temperature thereby raised from $- 42^{\circ}$. to $+ 5^{\circ}$, another mixture, in every respect the same as the last was made, which gave, on trial with a spirit-thermometer $- 43^{\circ}$. The mercury was now received into the cloth, and put gently into this new mixture, where it was left to be cooled still lower than before.

In the mean time five pounds of muriate of lime, in a large pail made of tinned iron, and japanned inside and outside, was placed in a cooling mixture in an earthen-ware pan. The mixture in the pan, which consisted of 4lb. of muriate of lime, and a like quantity of snow of the same temperature as the former, in one hour reduced the 5lb. of muriate in the pail to $- 15^{\circ}$. The mixture was then emptied out of the earthen pan, and four large corks, at proper distances, placed on its bottom to serve as rests for the japanned pail, which was now put into the pan. The corks answered the purpose of insulating the inner vessel, while the external one kept off the surrounding atmosphere; and preserved the air between the two at a low temperature.

To the 5lb. of muriate of lime which had been cooled as already noticed, to $- 15^{\circ}$, and which still remained in the metallic vessel, was now added snow, uncompressed and free from moisture, at the temperature of 32° . In less than three minutes it gave a temperature of $- 62^{\circ}$, a degree of cold which was never produced before in this country, being 94° below the freezing point of water.

The mercury which, by the immersion in the second cooling mixture to which it was exposed, was by this time, reduced to

— 30° , was now, by the means employed before, cautiously put into the last made mixture of the temperature of — 62° . A hoop, with net-work fastened to its upper edge, and of such a breadth in the rim, that the net-work, when loaded with the bladder of mercury, could not reach its lower edge, was at the bottom of the mixture to prevent the bladder from coming in contact with the vessel; by which means the mercury was suspended in the middle of the mixture. As soon as the bladder was safely deposited on the net-work, the vessels were carefully covered over with a cloth to impede the passage of heat from the surrounding atmosphere into the freezing materials. The condensation of moisture from the atmosphere, by the agency of so low a temperature was greater than could have been expected. It floated like steam over the vessels, and but for the interposed covering, would have given the mixture more temperature than was desirable.

After one hour and forty minutes they found, by means of a searcher introduced for the purpose, that the mercury was solid and fixed. The temperature of the mixture at this time was — 46° , that is 16° higher than when the mercury was put into it. As they had neglected to sling the hoop and net-work in such a manner as might have enabled them to lift it out of the mixture at once with the bladder and its contents, it was therefore necessary to turn out the whole contents of the pail into a large evaporating capsule made of iron. This was not effected without the mercury striking against its bottom and being fractured, though it received a considerable increase of temperature from the capsule. The fracture was similar to that of zinc, but with parts more cubical.

The large pieces were kept for some minutes before fusion took place, while others were twisted and bent into various forms, to the no small gratification and surprize of those who had never witnessed, or expected to see such an effect produced on so fusible a metal.

REMARK...In experiments of this kind all the exterior vessels should be of earthen-ware, glass, or wood, which being bad conductors of heat, prevent the ingredients from receiving it from the atmosphere, and surrounding objects, with the same facility that they would through metals ; and for a similar reason the interior vessels should be of metal, that they may allow the heat to pass more readily from the substance to be cooled into the frigorific mixture employed for that purpose. If this be attended to, a small quantity of mercury (2 to 4 oz.) may easily be frozen by means of the above mixture, in a pewter pint-pot placed in a bason.

ANALYSIS OF ORES OF MERCURY.

Ores of mercury are best analyzed by distilling them in a strong heat, and adapting a receiver half filled with water. The native cinnabar is decomposed by distilling it with one part of lime or iron filings, to three of the ore.

ZINC.

PART XLVIII.

SECT. I.

NATURAL HISTORY OF ZINC.

ZINC is found in nature combined with oxygen, carbonic acid, and sulphuric acid; and mineralized by sulphur. Native oxid of zinc is commonly called *calamine*. It occurs in a loose, and in a compact form, amorphous, of a white, grey, yellow, or brown colour, without lustre or transparency. Combined with carbonic acid, it is called *vitreous zinc ore*, or *native carbonate of zinc*. It is found in solid masses, sometimes in six-sided compressed prisms, both ends being covered with pentagons. Its colour is generally greyish inclining to black. It is often transparent. *Sulphate of zinc* is found efflorescent in the form of stalactites; or in rhombs. *Sulphuret of zinc*, or *blende*, is the most abundant ore. It is found of various colours; brown, yellow, hyacinth, black, &c. and with various degrees of lustre and

transparency. This zinc ore is contaminated with iron, lead, argillaceous and siliceous earths, &c. It occurs both in amorphous masses and crystallized in a diversity of polygonal figures.

PROPERTIES OF ZINC.

Zinc on its fracture appears of a shining white colour, with a bluish tint. It possesses some degree of ductility and may be extended when carefully passed between metallic cylinders in a flatting mill. Its specific gravity is 7.190. It melts at 700° Fahr. By a farther increase of heat it is volatilized without change. When melted in contact with the air, its surface becomes covered with an imperfect oxid; when heated a little above ignition it burns with a bright yellowish white flame, slightly tinged with green, and a white oxid is formed in light flakes, which are carried off by the rapid current of air in the burning metal. It undergoes very little alteration from the air, its surface becomes slightly tarnished. It is not acted on by water at the usual temperature of our atmosphere; but at that of ignition, it decomposes this fluid rapidly. It is oxidated and dissolved by the greater number of the acids. It has a very strong attraction for oxygen, and therefore precipitates the greater number of the metals from their acid solutions. All the alcalis when digested or boiled with zinc blacken its surface and dissolve a minute portion of it. It decomposes muriate of ammonia, sulphate of potash, and various other neutral salts. A mixture of nitrate of potash and zinc detonates with rapidity. Sulphur and zinc cannot be united by fusion. Gold, silver, platina, and nickel form brittle compounds with zinc. It easily unites with mercury and tin. It does not combine with lead or bismuth. The most frequent and at the same time most useful combination of zinc is that with copper. It unites with great difficulty to arsenic, iron, and cobalt. It inflames in oxygenated muriatic acid gas, and fulminates by pressure or a blow with oxygenated muriate of potash. It is a very strong conductor of galvanism.

METHOD OF OBTAINING ZINC.

In order to obtain zinc from its ores, they must first be torrifed, and then mixt with half their weight of charcoal powder, and distilled in an earthen retort three quarters full, and to which a receiver is luted, in a strong heat, gradually increased for some hours. The zinc in its metallic form is then found in the neck of the retort. In order to obtain the metal in a pure state dissolve it in diluted sulphuric acid, and boil the concentrated solution for a few minutes upon granulated zinc. Then filter it, and precipitate it by soda. Collect the precipitate, wash it, and when dry mix it with half its weight of charcoal-powder, and submit it to a red heat in an earthen retort. Pure zinc will then be found in the neck of the retort.

SECT. II.

EXPERIMENTAL PROOFS

OF

THE PROPERTIES OF ZINC.

EXPERIMENT I.

Zinc when exposed to a strong heat burns with a bright flame and is volatilized.

PLACE a large crucible on two bricks, in a good furnace; incline it, at an angle of 45° , and form before its aperture, a rest to support the cover, in order that the crucible may be shut when necessary.

Put zinc into the crucible, and fuse it by keeping the crucible shut. When of a red heat, uncover it, and a very bright white flame will rise from the surface of the zinc; flakes of exceedingly white and light matter, like cotton, will rise at the same time; this is *white oxid of zinc*. Remove the oxid with a long-handled iron spoon, and more oxid will be immediately formed, which must be removed in like manner. This operation is to be continued till the whole of the zinc is converted into an oxid.

EXPERIMENT II.

Zinc unites with phosphorus by fusion.

Put into an earthen retort two parts of filings of zinc and one of phosphorus, and having adapted a receiver to the neck of the retort, proceed to distillation.

The product will be a little phosphorus in the receiver; the neck of the retort will contain, 1. zinc in a metallic form; 2. a sublimation of a red efflorescence; 3. white oxid of zinc; 4. a sublimation in needles, having a metallic appearance, with a slight tint of blue, and prismatic. Or,

A phosphuret of zinc may be obtained by projecting small pieces of phosphorus well dried, upon zinc broken also into small pieces, and brought to a red-heat in a crucible. As the zinc enters into fusion project the phosphorus, and at the same time small bits of resin, to prevent the oxidation of the zinc. When the crucible is taken from the fire its contents will be a metallic substance, which is phosphuret of zinc.

EXPERIMENT III.

Zinc decomposes nitric acid readily.

Put granulated zinc into a Florence flask, and pour over it weak nitric acid: a strong effervescence will take place, and nitrous gas will be disengaged in a large quantity.

The solution of nitrate of zinc has a yellow colour, and when newly made is somewhat turbid, but becomes gradually transparent.

By evaporation it furnishes crystals in tetrahedral prisms, terminated by pyramids of four faces, which are striated and attract moisture from the air.

EXPERIMENT IV.

Zinc detonates rapidly with nitrate of potash.

Mix equal parts of nitrate of potash and filings of zinc, and project the mixture by spoonfuls into a crucible which has been brought to a state of ignition. When the powder has acquired a certain degree of heat, a strong detonation suddenly takes place; as soon as it ceases throw another spoonful of the mixture into the vessel, and repeat the operation till the whole quantity is consumed. The residuum will be an oxid of zinc.

REMARK...This experiment requires a great deal of caution to prevent accidents.

EXPERIMENT V.

Zinc detonates, by percussion, with oxygenated muriate of potash.

When a few grains of fine zinc filings and oxygenated muriate of potash are struck on an anvil, a violent detonation takes place, with a white flame.

EXPERIMENT VI.

Zinc decomposes muriate of mercury.

Distil two parts of muriate of mercury and one of zinc, in a glass retort; a salt which crystallizes in small needles united together will be sublimed, and the mercury will remain fluid in the retort. This salt is muriate of zinc.

ANALYSIS OF ORES OF ZINC.

For extracting zinc from the ore called *blende*, let one part of the powdered ore be gently boiled in six of diluted nitric acid in a flask to dryness, and repeat this operation with the same ore two or three times. Then dissolve the dry mass in a sufficient quantity of water to which about one-fourth part of nitric acid has been added, and precipitate the fluid by a solution of soda. Collect the precipitate on a filter, wash it by passing water over it, and re-dissolve it in muriatic acid. Then decompose this solution by liquid ammonia in excess, in order to separate the iron, lead, and alumine which may have been dissolved. If this precipitate be boiled in four times its quantity of potash the alumine will be separated.

From the before-going solution the zinc may be separated by the addition of an acid. It may be reduced to the metallic state by strongly igniting it with half its weight of charcoal in a closed crucible.

In order to analyze *calamine*, let it be digested repeatedly in diluted nitric acid, and the insoluble residue be boiled in concentrated muriatic acid three times. What remains after ablu-tion with boiling water is *silex*.

The nitric solution obtained before, contains the zinc, and also iron and alumine, if they were present in the ore. Let therefore the solution be evaporated to dryness, re-dissolve it in nitric acid, and evaporate it again as before, in order to render the iron as insoluble as possible. Then dissolve the mass in water.

A tolerably exact assay of the ore called *calamine*, may be made in the following manner:

Mix any quantity of the pulverized ore, previously freed from sulphur by roasting, with one-eighth part of charcoal powder. Put this mixture into a crucible capable of containing thrice the quantity. Diffuse equally amongst this mixture a quantity of small grains or thin plates of copper equal to that of the *cala-*

mine or ore employed, and upon the whole lay another equal quantity of grains or plates of copper, and lastly, cover this latter portion with charcoal powder. Lute a cover upon the crucible, and apply a red heat during one or two hours. The volatilized zinc will thus combine with the copper and convert it into brass. By comparing the weight of the metal after the operation, with the weight of the copper employed; the quantity of zinc united with the copper will be known.

The copper which has not been converted into brass, or more copper with fresh charcoal powder may be again added in the same manner to the remaining ore, and the operation repeated with a heat somewhat more intense, in order that any zinc remaining in the ore may be thus extracted. A curious circumstance is, that a much greater heat is required to obtain zinc from its ore without the interposition of copper, than in the process now described of making brass; in which the separation of the zinc from its ore is certainly facilitated by the interposition of the copper.

*Class IV....*VERY DUCTILE AND EASILY OXIDABLE METALS.

TIN.

PART XLIX.

SECT. I.

NATURAL HISTORY OF TIN.



IT has been much doubted whether tin is ever found native. In the opinion of Kirwan there are sufficient authorities to determine the question in the affirmative. The *native oxid of tin*, or *tin stone*, occurs both massive and crystallized. Its colour is a dark brown, sometimes yellowish grey. When crystallized, it is somewhat transparent. The *wood tin ore* is a variety of the native oxid, termed so from its fibrous texture. This variety has hitherto been found only in Cornwall. It occurs in fragments which are generally round, and its colour is brown, sometimes inclining to yellow. Tin is also found mineralized by sulphur, associated always with a portion of copper, and often of iron.

This ore is called *tin pyrites*. Its colour is yellowish grey. It has a metallic lustre, and a fibrous, or lamellated texture; sometimes it exhibits prismatic colours. Tin is comparatively a rare metal, as it is not found in great quantity any where but in Cornwall or Devonshire; though it is likewise met with in the mines of Bohemia, Saxony, the island of Banca, the peninsula of Malacca, and in the East Indies.

PROPERTIES OF TIN.

Tin is of a brilliant white colour, though not quite so white as silver. It is one of the lightest of the metals; its specific gravity, when hammered, being 7.299. It is very fusible, melting at about 410° Fahr. By intense heat it is volatilized. It becomes oxidated by a moderate degree of heat. It easily bends and emits a noise, called the crackling of tin. It is exceedingly soft and ductile. It may be reduced to very thin leaves. *Tin foil*, or tin leaf, which is tin beat out, is about $\frac{1}{1000}$ part of an inch thick. It has scarcely any sound. It resists the action of the air. It crystallizes in rhombs formed of small octahedra. It unites, by fusion, with phosphorus and sulphur. It does not decompose water alone, or in the cold; but easily by means of many other bodies. It decomposes the sulphuric acid, and unites with the sulphureous acid. It decomposes the nitric acid, and is very soluble in muriatic acid. Nitromuriatic acid acts on it very readily. It is slightly soluble in the fluoric and boracic acids. Phosphoric acid attacks it by heat. Tartareous acid has no perceptible action on it. The oxalic and acetic acids dissolve it in small quantities. The alcalies appear to have some action on it by heat. It combines with sulphuret of potash by fusion. It unites with the greater number of the metals with facility. It decomposes muriate of mercury, and muriate of ammonia. It causes nitrate of potash to detonate. It takes fire spontaneously in oxygenated muriatic acid gas, and is capable of combining with two different proportions of oxygen.

METHOD OF OBTAINING TIN.

In order to obtain tin from its ore, a mere fusion of it, with pounded charcoal, is sufficient. Or, a certain quantity of the ore is first freed from sulphur and arsenic by torrifaction; after which it is mixed with equal parts of potash, one half of common resin, and two parts of black flux; the mixture is then fused in a crucible covered with charcoal, by means of which the metal is recovered in its metallic state. In order to obtain pure tin, let the tin obtained before be rapidly dissolved in strong nitric acid with heat. Thus some of the metals it may contain will be held in solution, and others become oxidated, but muriatic, or nitro-muriatic acid will, on digestion, take up these oxids, and after sufficient ablution, leave that of tin, which may afterwards be reduced by mixing it when pulverized with double its weight of a flux formed of equal parts of pitch and borax, or resin and borax, and putting it into a covered crucible, lined with charcoal, which must be placed in a forge, and strongly heated for a quarter of an hour.

SECT. II.

EXPERIMENTAL PROOFS

OF

THE PROPERTIES OF TIN.

EXPERIMENT I.

Tin unites to oxigen in different proportions.

LET this metal be melted in an iron ladle in contact with air; its surface will become covered with a grey pellicle, which forms wrinkles; when this is taken off, it is soon succeeded by another, and in this manner the whole metal may be converted into a powder, which is *yellow* or *grey oxid of tin*. To free it from the particles of tin which are not oxidated, it must be passed through a sieve of lawn or silk. It is extremely difficult to separate it entirely from the tin, it therefore is of a grey colour.

Let the oxid of tin, obtained in the above process, be exposed to a red-heat in a crucible, or an earthen capsule under a muffle for some time, stirring it occasionally with an iron rod, and it will become more oxidated, and acquire a white colour. This is *white oxid of tin*, commonly called *putty of tin*. It is used for polishing glass specula for telescopes, marble, steel, &c. It deprives every kind of glass of its transparency, and converts it into *white enamel*.

The *yellow oxid of tin* may also be obtained by dissolving tin filings in diluted nitric acid, without the assistance of heat, and then precipitating the solution by potash.

The *white oxid of tin* may be obtained by heating tin in concentrated nitric acid, a violent effervescence ensues, and the whole of the tin is converted into a white powder, which is deposited at the bottom of the vessel.

EXPERIMENT II.

White oxid of tin combines with sulphur by fusion, and forms yellow sulphurated oxid of tin, (aurum musivum.)

The process generally adhered to in this preparation is as follows: Twelve parts of tin are melted in a crucible by a brisk fire, and three of mercury added to it. This mass is to be reduced to powder in a stone mortar, and then intimately mixed by trituration with seven parts of sulphur, and three of muriate of ammonia: the mixture is exposed to heat as long as any white vapours are disengaged; the heat is then moderately increased; a little sulphuret of mercury, and some oxygenated muriate of tin sublime, and the *aurum musivum* remains at the bottom of the matrass.

A variation in the proportion of the ingredients produces no very essential change in the result. Pelletier obtained a very beautiful musive gold by distilling together equal parts of mercury, muriate of ammonia, tin, and sulphur. The main point is the proper regulation of the heat; if this be too strong the operation does not succeed, and instead of a beautiful *aurum musivum*, common sulphuret of tin, of a very dark colour, is obtained.

RATIONALE. The theory of the formation of this compound is one of the most intricate in chemistry, but it appears to have

been sufficiently ascertained by the researches of Pelletier. In the first amalgamation and trituration of the mercury and tin, the latter is divided, and in some degree oxidated; when the mixture of this amalgam with the sulphur and muriate of ammonia is heated, the muriatic acid, by a disposing affinity, enables the tin to be oxidated by decomposing the water, and this oxid combines with the muriatic acid; the hydrogen of the water is disengaged with the ammonia of the muriate of ammonia; this ammonia unites with a portion of the sulphur, and forms sulphuret of ammonia, which being disengaged, causes the white fumes. The heat being now augmented, the muriate of tin is again decomposed, the oxid of the metal attracting a portion of the sulphur, and forming the *aurum musivum*. Such is the aetiology of that complicated process given by Pelletier.

Aurum musivum is employed to give a beautiful colour to bronze, and to excite the strength of electrical machines. It is used by japanners, and for many articles intended to have the appearance of metallic gold.

EXPERIMENT III.

Tin decomposes nitric acid with great rapidity, and forms ammonia by the addition of an alkali.

Moisten some powdered tin with concentrated nitric acid, and when the red fumes have ceased to arise, add some solution of potash. A strong smell of ammonia will be immediately produced.

RATIONALE...In this case the tin decomposes both the nitric acid and the water: the hydrogen of the latter, and the nitrogen of the former being presented to each other in their nascent state, by the addition of the alkali, unite and form ammonia which is disengaged.

EXPERIMENT IV.

Tin combines very readily with sulphur.

This sulphuret may be obtained by fusing together in a covered crucible, one part of tin with four or five of sulphur. The compound is heavier than tin, and not so fusible.

EXPERIMENT V.

Tin combines also with phosphorus.

Take equal parts of tin filings and glacial acid of phosphorus, and one eighth part of charcoal-powder: mix these three substances intimately, and fuse them in a crucible; a few grains of a metallic appearance, and of a pretty large size will be obtained. These do not differ in appearance from tin, but when melted by the blow-pipe, the phosphorus abandons the metal and burns on its surface.

REMARK...In fusing tin with charcoal-powder and glacial acid of phosphorus, care must be taken to regulate the fire properly, for the phosphorus easily abandons the metal.

EXPERIMENT VI.

Tin is soluble in sulphuric acid.

Put into a matrass five parts of concentrated sulphuric acid, and one part of tin in grains; place the vessel on a sand-bath, and the tin will dissolve without any effervescence; sulphureous acid will be disengaged, and sulphur will be formed, which remains liquid at the surface of the solution while warm, but precipitates when it cools.

This solution is of a dark brown colour when first prepared, but becomes transparent by rest.

If it be long exposed to heat the tin is precipitated in the form of a white oxid.

This solution furnishes crystals in fine needles interwoven with each other, called *sulphate of tin*.

EXPERIMENT VII.

Tin is soluble in muriatic acid.

Put one part of tin into a matrass, pour over it two of concentrated muriatic acid, and place the vessel on a sand-bath; hydrogen gas will be evolved, and a solution of a light amber colour will remain in the matrass.

If the solution be evaporated, brilliant and very regular crystals will be obtained, which are *muriate of tin*.

EXPERIMENT VIII.

Tin is soluble in nitro-muriatic acid.

Put two parts of nitro-muriatic acid into a Florence flask, add gradually one part of tin; if the heat be too great, the vessel must be plunged into cold water to diminish it. This solution is of a reddish brown colour, and often forms in a few moments a viscous trembling jelly. If the solution be diluted with about half its weight of water, it becomes concrete, and is of an opal colour.

EXPERIMENT IX.

Tin decomposes muriate of ammonia.

Take equal parts of granulated tin and muriate of ammonia, introduce the mixture into a retort, and adapt to it a receiver in the mercurial pneumatic trough. As soon as the retort is heated, a decomposition takes place, the ammonia is disengaged in the form of gas, and the residuum is a *solid muriate of tin*, decomposable by water.

EXPERIMENT X.

Tin decomposes muriate of mercury.

In order to obtain this combination, which was formerly known by the name of *Libavius's smoking liquor*, fuse in an iron spoon five parts of tin, add one of mercury, and triturate the mixture in a marble mortar, with an equal quantity of oxygenated muriate of mercury. Put the mixture into a glass retort, and adapt to the neck of it a middle-sized receiver; place the retort on a sand-bath, and proceed to distillation.

A colourless fluid will first pass over, a thick white vapour will then burst out with a kind of explosion, and cover the sides of the receiver. This vapour is condensed into a transparent liquor, which exhales thick, white, and very abundant fumes: this is the *oxygenated muriate of tin*.

REMARK...Adet has published a very interesting memoir on this production. From the observations of this chemist it appears, 1st. That the oxygenated muriate of tin is a saline substance, formed by the combination of tin with oxygenated muriatic acid deprived of water. 2d. That if it be mixed with water in the proportion of seven to twenty-two, a concrete saline substance will be obtained. 3d. That when diluted with water, it can dissolve a new quantity of tin without a disengagement of hydrogen gas. According to these facts, it is a true *oxygenated muriate of tin*.

EXPERIMENT XI.

Tin is soluble in liquid potash, soda, &c.

If a very concentrated solution of potash, or soda, be mixed with tin filings, or tin foil, and boiled, part of the metal will be dissolved; for on adding an acid, the solution will be decomposed, and the tin be precipitated.

EXPERIMENT XII.

Tin causes nitrate of potash to detonate.

For this purpose fuse tin in a crucible, and make it somewhat red; then project over it pounded nitrate of potash exceedingly dry; a deflagration will take place, and a brilliant white flame will arise. Add a new quantity of nitrate of potash till no more detonation ensues; remove the crucible from the fire, and having separated the contents from it, wash them in water, filter the liquor which contains the potash of the nitrate, and the remainder on the filter will be oxid of tin, mixed with a little alcali rendered caustic by the tin. Care, therefore, must be taken to wash it well, and a small quantity of acid may be added, in order to precipitate the oxid of tin.

EXPERIMENT XIII.

Tin detonates with oxigenated muriate of potash by percussion.

If a few grains of finely divided tin be mixed with double the quantity of oxigenated muriate of potash, a compound will be formed which detonates loudly by percussion.

EXPERIMENT XIV.

Accension of tin-foil by nitrate of copper.

Spread thinly, on a piece of tin-foil, three or four inches square, some dry nitrate of copper, and wrap it up. No effect will follow. Unfold the tin-foil, and sprinkle the nitrate of copper with a very little water; wrap it up again as quickly as possible, pressing down the edges closely. Considerable heat attended with fumes will now be excited; and if the experiment

has been dexterously managed, even light will be evolved. This shows that nitrate of copper has no action on tin till in a state of solution.

REMARK...This is a common experiment, shown by teachers of chemistry, to prove that bodies do not act on each other in a dry state. But there seems to be an error with regard to the action of nitric acid on tin; for nitric acid, freed as much as possible from water, will not act upon tin at all; the action only takes place when the acid is diluted. Hence the rationale of this experiment must be sought for in the action of the water on the nitric acid of the nitrate of copper.

EXPERIMENT XV.

Tinning copper vessels,

Vessels of copper, especially when used as kitchen utensils, are usually covered with a thin coat of tin to prevent the copper from oxidating, and to preserve the food which is prepared in them from being mixed with any of that poisonous metal. These vessels are then said to be *tinned*. Their interior surface is scraped very clean with an iron instrument, and rubbed over with muriate of ammonia. The vessel is then heated, and a little pitch thrown into it, and allowed to spread on the surface. Then a bit of tin is applied all over the hot copper, which instantly assumes a silvery whiteness. The intention of the previous steps of the process is to have the surface of the copper perfectly pure and metallic; for tin will not combine with the oxid of copper. The coat of tin thus applied is exceedingly thin. Bayen ascertained, that a pan nine inches in diameter, and three inches three lines in depth, when tinned, only acquired an additional weight of 21 grains. Nor is there any method of making the coat thicker. More tin indeed may be applied, but a moderate heat melts it, and causes it to run off.

EXPERIMENT XVI.

Tinning iron.

Iron is tinned in the following manner: Plates of iron, after being reduced to a proper thickness, are immersed in water acidulated with sulphuric or muriatic acid, in order to clean them compleately from rust; they are then scoured quite bright, and placed in a pot, or other convenient vessel, filled with melted tin, whose surface is covered with suet, pitch, or resin, to prevent the surface of the tin being oxidated. The plates of iron being then suffered to pass through it, the tin will unite with them so as to cover each side of the plate with a thin white coat. They are then what are called tin-plates.

In the same way stirrups, buckles, bridle-bits, &c. are covered with coats of tin.

EXPERIMENT XVII.

Silvering looking glasses.

Looking glasses are covered on one side with an amalgam of tin and mercury. For that purpose tin-foil is evenly placed on a flat stone, or table; and quicksilver, in which some tin already has been dissolved is poured upon it, and spread with a feather, or bunch of cloth, until its union has brightly lined every part. A plate of glass is then cautiously slid upon it from one end to the other, in such a manner that part of the redundant mercury is driven off, or swept away, before its edge. The remainder is now united to the tin. The glass is then loaded with weights all over, so as to press out still more of the mercury; by inclining now the table this remaining quantity of the superfluous mercury becomes

discharged, and in a few hours the rest of the tin-foil, and mercury, adheres so firmly to the glass, that the weights may be removed without any danger of its falling off.

In the small way about 2 ounces of mercury are requisite for covering three square feet of glass.

ANALYSIS OF ORES OF TIN.

In order to analyze the ore called *tin-stone*, let one part of it be pulverized and digested with six of concentrated sulphuric acid, for at least six hours. Then decant the fluid, dilute it with water and filter it. The residue consists of silex. Having done this, add to the solution, dissolved potash as long as a precipitate ensues. Then collect the precipitate by transferring the whole on a filter, wash it repeatedly, and when dry, reduce it, by fusing it with half its weight, or less, of charcoal-powder. If the iron which it contained is wished to be separated, it may be precipitated from the solution in sulphuric acid, by the addition of triple prussiate of potash.

The ore may be analyzed in the dry way in the following manner: Let one part of the ore be fused with six of potash, and dissolve the mass in a sufficient quantity of water. The insoluble residue must be several times fused with a like quantity of potash, and dissolved in water. The residue, if any, may then be dissolved in muriatic acid by heat. The alkaline solutions must be mingled together, and decomposed by adding to them a solution of carbonate of soda. The obtained precipitate must then be dissolved in muriatic acid, and mixed with the solution in muriatic acid obtained before. If plates of zinc be now immersed in the solution, the tin will be precipitated. The iron may be separated from the solution, if deemed necessary, by a solution of triple prussiate of potash.

LEAD.

PART L.

SECT. I.

NATURAL HISTORY OF LEAD.

THIS metal is found in considerable quantity in many parts of the earth. It is found in nature in different states, seldom if at all in the metallic state. It is found in that of an oxid, *red lead ore*, mixed with a portion of iron, clay, and other earths.

The colour of this ore is aurora red, resembling red arsenic. It is found in small lumps of an indeterminate figure, and also crystallized in four-sided rhomboidal prisms.

Combined with carbonic acid it forms the *sparry lead ore*, so called because it has the texture and crystallization of certain spars. There are a great many varieties of this kind. It is found united with sulphuric, phosphoric, arsenic, molybdic, and chromic acids. Lastly, lead is found mineralized by sulphur forming what is called *galena* (*sulphuret of lead*) which is by far its most abundant ore. This ore which is very common is found both in masses and crystals.

The primitive form of its crystals is a cube. Its colour is of a bluish lead grey. It has a considerable metallic lustre, its texture is foliated. It stains the fingers, and often feels greasy. It contains in general a minute quantity of silver.

PROPERTIES OF LEAD.

Lead is of a bluish-white colour when fresh cut. It is malleable. It soon tarnishes in the atmosphere. It may easily be cut with a knife, and stains the fingers bluish-grey when rubbed. It fuses at 540° Fahr. and renders other more refractory metals fusible. It becomes vitrified in a strong and continued heat, and vitrifies various other metals. It is the least elastic of all the metals. It is very laminable, but it possesses very little ductility. Its specific gravity is 11.435. It crystallizes by cooling in small octahedra. When fused its surface first becomes yellow and then red. It unites by fusion with phosphorus and sulphur. The greater part of the acids act upon it. The sulphuric acid requires the assistance of a boiling heat. Nitric acid is decomposed by it. Muriatic acid acts very weakly on it. Acetic acid dissolves it. Fluoric acid attacks it by heat, and slightly in the cold. It combines with other metals, but few of its alloys are applied to any use. When combined with mercury it forms a crystallizable alloy which becomes fluid when triturated with that of bismuth.

METHOD OF OBTAINING LEAD.

In order to obtain lead in the great way the ore is picked from among the extraneous matter with which it was naturally mixed. It is then pulverized and washed. It is next roasted in a reverberatory furnace in which it is to be agitated, in order to bring all its surfaces in contact with the air. When the external parts begin to soften, or assume the form of a paste, it is covered with charcoal, the mixture is stirred, and the heat increased gradually; the lead then runs on all sides, and is collected at the bottom of the furnace, which is perforated so as to permit the metal to flow into a receptacle defended by a lining of charcoal.

The scoria remaining above in the furnace still retain a considerable proportion of lead; in order to extract it the scoria

must be fused in a blast furnace. The lead is by that means separated, and cast into iron moulds, each of which contains a portion called a *pig of lead*. These pigs are sold under the name of *ore lead*.

To disengage the silver from lead thus obtained, the metal is subjected to the action of the refining furnace. The continual application of a quantity of fresh air which is thrown by means of large bellows upon the fused lead, which is at the same time heated as intensely as possibly, oxidates the lead, and converts it into the yellow scaly oxid, known by the name of *lytharge*.

This scaly oxid being driven off from the surface of the fused metal, as it is formed, leaves the silver alone unaltered at the bottom.

The lytharge is then to be fused in contact with charcoal, that it may assume the properties of metallic lead.

In order to obtain perfectly pure lead, the lead of commerce may be dissolved in pure nitric acid, and the solution be decomposed by adding to it, gradually, a solution of sulphate of soda, so long as a precipitate ensues. This precipitate, which is sulphate of lead, must then be collected on a filter, washed repeatedly in distilled water, and then dried. In order to reduce it to its metallic state, let it be mixed with two or three times its weight of black flux, introduce the mixture into a crucible, and expose it briskly to a red heat.

SECT. II.

EXPERIMENTAL PROOFS
OF
THE PROPERTIES OF LEAD.

EXPERIMENT I.

Lead unites to oxygen in different proportions.

PUT into an iron ladle any quantity of lead, and place it over the fire; as soon as the metal is fused, it becomes oxidated at the surface; a grey pellicle is formed, which, on being removed, is soon succeeded by another, and in this manner the whole of the lead may be converted into a dirty grey powder which is *grey oxid of lead*.

If the oxid obtained in the above process be exposed to a low red-heat it acquires a dirty yellow colour. This is what is called *common massicot*. By continuing the oxidation, the oxid assumes a dark yellow colour, and in that state is *yellow oxid of lead*, formerly called *yellow massicot*.

If the yellow oxid, obtained as above, be exposed to a still stronger heat in a reverberating furnace, not capable of bringing it to a state of fusion, it will continue to increase in colour, and at length become of a beautiful red. This is *red oxid of lead*, or *minium*.

By exposing the red oxid of lead to a heat capable of reducing it to a state of semi-vitrification, its parts become agglutinated into small thin scales, which always preserve their red colour, but have less brightness. The oxid now is called *semi-vitreous oxid of lead*, or *litharge*.

If the red or semi-vitreous oxid of lead be exposed to heat in a crucible, and the fire raised by degrees, it enters into fusion, but with much more difficulty than lead, and becomes converted into glass: this glass, however, has so much action on earthy substances, that it penetrates the common crucibles, and makes them enter into fusion.

This inconvenience may be obviated by mixing one part of sand with three of the red oxid; put this mixture into a good crucible, place it under the muffle of a furnace and keep it at a white heat for two or three hours, or until the matter be fused. By this means *glass of lead* will be obtained, approaching in colour to amber. This vitreous oxid of lead constitutes the basis of the glazing for common pottery.

EXPERIMENT II.

The oxids of lead decompose muriate of soda and muriate of ammonia.

Mix two parts of fine powdered red oxid of lead with one of common salt in a stone mortar, and form the two into a paste with a little water, adding more occasionally, as the mixture becomes dry.

The soda of the common salt will be disengaged and the muriatic acid will unite with the oxid of lead. Wash off the soda, dry the white mass, and fuse it in a crucible, it will form the beautiful and durable pigment called *patent* or *mineral yellow*.

The decomposition of muriate of ammonia may be effected in a similar manner by the help of caloric.

EXPERIMENT III.

Lead combines with sulphur by fusion.

Fuse three parts of lead in an iron ladle; add one part of powdered sulphur and stir the mixture; the sulphur will speedily

combine with the lead and form a black and somewhat scaly powder. This matter will not enter into fusion until it has been brought to a red heat; it then forms a black brittle mass, disposed in facets, much less fusible than lead. This is *sulphuret of lead*, or *artificial galena*.

EXPERIMENT IV.

Lead unites with phosphorus by fusion.

If a mixture of equal parts of filings of lead, and glacial acid of phosphorus be fused in a crucible, with one-eighth part of powdered charcoal, a button will be obtained, which differs very little in appearance from lead. It is malleable, but separates into thin plates when hammered, and may be easily cut with a knife. It loses its brilliancy much sooner than lead; and when fused by the blow-pipe on charcoal, the phosphorus burns, and abandons the lead.

Phosphuret of lead may also be formed by dropping pieces of phosphorus into melted lead, and covering the crucible as expeditiously as possible.

EXPERIMENT V.

Lead and tin form an alloy which is more fusible than either of the metals separate.

This alloy, which is known by the name of plumbers solder, is made by fusing together, in an iron ladle, two parts of lead and one of tin.

EXPERIMENT VI.

Lead precipitates silver or mercury from their solutions.

Suspend a piece of lead, scraped bright, in a concentrated solution of nitrate of silver, or nitrate of mercury. The lead, by

its greater affinity for oxygen, will first become black, and then separate the silver or mercury from the solution.

A similar effect will take place by distilling muriate of mercury with granulated lead. Mercury will pass over into the receiver, and muriate of lead remain in the retort.

The greater part of the acids act upon lead, and form saline compounds, which will be noticed hereafter.

EXPERIMENT VII.

Zinc precipitates lead in a metallic state.

(Lead-tree.)

Dissolve one part of acetite of lead in thirty-six or forty of distilled water; put this solution into a white glass bottle, suspend a cylinder or ball of zinc in it, and then leave the vessel containing it undisturbed. The zinc will soon become covered with a moss-like substance which increases gradually, shooting out symmetrical leaves of a metallic splendor, which arrange themselves into a kind of tree.

RATIONALE...The explanation of this experiment is obvious; the zinc has a greater affinity for oxygen than the lead has, it therefore deprives the latter of it, which being thus reduced to the metallic state, arranges itself by virtue of its molecular attraction into a symmetrical form.

ANALYSIS OF ORES OF LEAD.

In order to assay lead ores, different ways are made use of, according to the nature or composition of those ores. When in the state of an oxid, or combined with oxygen, (*red lead ore*) it may be dissolved in nitric acid, and precipitated from it in the

metallic state by zinc. If the ore contains silver, the solution is to be much diluted with distilled water, and the silver separated by muriatic acid; after which the lead may be precipitated either by zinc or an alkali.

Or, the oxid may be merely fused with charcoal, which separates the oxygen and sets the lead free.

Argentiferous antimoniated lead ore was thus analyzed by Klaproth: It was digested with seven times its weight of nitric acid, by which part was dissolved. The residuum was treated repeatedly with muriatic acid, which was poured off while boiling hot. What remained undissolved was sulphur, mixed with a little silex. Common salt being added to the nitric solution two precipitates appeared, 1. A heavy flaky one, which was muriate of silver: 2. Acicular crystals of muriate of lead. These crystals were dissolved in water, and the solution added to the nitric solution. From this solution sulphate of soda precipitated a heavy white powder, which was sulphate of lead. Lastly, ammonia afforded a precipitate, which was a mixture of iron and alumine. The muriated solution being concentrated, crystals of muriate of lead appeared; the concentration was continued as long as any crystals formed. The residuum being diluted with water, gave a white precipitate, which was oxid of antimony.

The *sparry lead ore* or carbonate of lead, may be analyzed in the following manner: Let one part of the ore, reduced to powder be dissolved in ten parts of nitric acid, and boil down the solution to one-third. The iron and antimony, if any be present, will be separated, and may be estimated by dissolving the precipitate in muriatic acid. If water be added to this solution, the antimony which was present will be separated, and on adding ammonia the iron becomes disengaged. In order to ascertain the quantity of lead which was contained in the ore, the nitric solution must be precipitated by the addition of sulphuric acid. The precipitate after being washed, must be dried and weighed; after deducting 70 per cent. the remainder shews the quantity of lead it contains.

Phosphate of lead may be dissolved in boiling muriatic acid. The solution is to be diluted with water till the crystals of muriate of lead are dissolved: being then saturated with ammonia, the lead and iron are precipitated. Dissolve the precipitate in muriatic acid, evaporate to dryness, and treat the dry mass with alcohol. The muriate of iron is dissolved; but the muriate of lead remains. Finally, drop lime water into the ammoniacal solution as long as any precipitate appears. That precipitate indicates the proportion of phosphoric acid.

Arseniate of lead has not been analyzed. It might be treated with an alkali, which would separate the lead. This metallic precipitate is then to be re-dissolved in nitric acid, and analyzed by the methods above described. The alkaline arseniate may be dissolved in water, and treated with nitrate of lead; 100 parts of the dry precipitate will indicate 33 of lead.

The sulphurated lead ores or *galenas*, may likewise be analyzed by first depriving them of the sulphur by torrefaction, and afterwards fusing them with two parts of black flux and half a part of iron filings, in a covered crucible, for half an hour; by this means the iron takes up the remaining sulphur; the alcali of the flux promotes the fusion, while its carbon carries off the oxygen; and thus the metal is recovered.

In order to obtain pure lead, let the lead of commerce be dissolved in nitric acid, and precipitate it by means of sulphate of soda. The precipitate, which is a sulphate of lead, after being washed, may be reduced in a crucible, by fusing it with three times its weight of black flux.

IRON.

PART LI.

SECT. I.

NATURAL HISTORY OF IRON.

OF all the metals there is none which is so copiously and so variously dispersed through nature as iron. In animals, in vegetables, and in all parts of the mineral kingdom we detect its presence. Mineralogists are not agreed with respect to the existence of native iron, though immense masses of it have been discovered, which could not have been the products of art; but there is much in favour of the notion that these specimens have been extracted by subterraneous fire. A mass of native iron, of 1600 pounds weight, was found by Pallas, on the river Denisei, in Siberia; and another mass of 300 pounds was found in Paraguay, of which specimens have been distributed every where. A piece of native iron, of two pounds weight, has been also met with at Kamsdorf, in the territories of Neustadt, which is still preserved there. These masses evidently did not originate in the places where they were found.

There are a vast variety of iron ores ; they may, however, be all arranged under the following genera ; namely, sulphurets, carburets, oxids, and salts of iron. The sulphurets of iron form the ores called *pyrites*, of which there are many varieties. Their colour is, in general, a straw-yellow, with a metallic lustre. They are often amorphous, and often also crystallized. Iron ores of this kind are known by the name of *mundick*. Iron, in the state of a carburet, forms the *graphite* of Werner, (*plumbago*). This mineral occurs in kidney-form lumps of various sizes. Its colour is a dark iron-grey, or brownish black ; when cut, blueish grey. It has a metallic lustre. Its texture is fine grained. It is very brittle. The combination of iron with oxygen is very abundant. The common *magnetic iron stone*, *magnetical pyrites*, or *load-stone*, belongs to this class : As does *specular iron ore*, and all the different ores called *hematites*, or *blood-stone*. Iron, combined with silex, constitutes *emery*. Iron, united to carbonic acid, exists in the *sparry iron ore*. Joined to arsenic acid it exists in the ores called *arseniate of iron*, and *arseniate of iron and copper*.

PROPERTIES OF IRON.

Iron is distinguished from every other metal by its magnetical properties. It is attracted by the magnet, and acquires, under various conditions, the property of magnetism. Pure iron is of a whitish grey, or rather blueish colour, very slightly livid ; but when polished, it has a great deal of brilliancy. Its texture is either fibrous, fine grained, or in dense plates. Its specific gravity varies from 7.6 to 7.8. It is the hardest and most elastic of all the metals. It is extremely ductile, and may therefore be drawn into wire as fine as a human hair, it is also more tenacious than any other metal, and consequently yields with equal facility to pressure. It is extremely infusible, and when not in contact with the fuel it cannot be melted by the heat which any furnace can excite ; it is, however, softened by heat, still pre-

serving its ductility; this constitutes the valuable property of *welding*. It is very dilatable by heat. It is the only metal which takes fire by the collision of flint. Heated by the contact of air it becomes oxidated. If intensely and briskly heated, it takes fire with scintillation, and becomes a black oxid. It combines with carbon, and forms what is called steel. It combines with phosphorus in a direct and in an indirect manner, and unites with sulphur readily by mixture in the cold with water, and by fusion. It decomposes water in the cold slowly, but rapidly when ignited. It decomposes most of the metallic oxids. All acids act upon iron. Very concentrated sulphuric acid has little or no effect upon it, but when diluted it oxidates it rapidly. The nitric acid oxidates it with great vehemence. Muriate of ammonia is decomposed by it. Nitrate of potash detonates very vigorously with it. Iron is likewise dissolved by alkaline sulphurets. It is capable of combining with a number of metals. It does not unite with lead or bismuth, and very feebly with mercury. It detonates by percussion with the oxygenated muriates.

METHOD OF OBTAINING IRON.

The general process by which iron is extracted from its ores, is first to roast them by a strong heat, to expel the sulphur, carbonic acid, and other mineralizers which can be separated by heat. The remaining ore, being reduced to small pieces, is mixed with charcoal, or coke; and is then exposed to an intense heat in a close furnace excited by bellows, the oxygen then combines with the carbon, forming carbonic acid gas during the process, and the oxid is reduced to its metallic state. There are likewise some fluxes necessary in order to facilitate the separation of the melted metal. The matrix of the iron ore is generally either argillaceous or calcareous, or sometimes a portion of siliceous earth; but whichever of these earths is present, the addition of one or both of the others makes a proper flux. These are therefore added in the due proportion according to the

nature of the ores; and this mixture, *in contact with the fuel*, is exposed to a heat sufficient to reduce the oxid to its metallic state.

The metal thus obtained, and called smelted, pig, or cast-iron, is far from being pure, always retaining a considerable quantity of carbon and oxygen, as well as several heterogeneous ingredients. According as one or other of these predominates, the property of the metal differs. Where the oxygen is present in a large proportion, the colour of the iron is whitish grey, it is extremely brittle, and its fracture exhibits an appearance of crystallization: where the carbon exceeds, it is of a dark grey, inclining to blue or black, and is less brittle. The former is the *white*, the latter the *black crude iron of commerce*. The *grey* is intermediate to both. In any of these states, the iron is much more fusible than when pure; hence it can be fused and cast into any form; and when suffered to cool slowly, it crystallizes in octahedra: it is also much more brittle, and cannot therefore be either flattened under the hammer, or by the laminating rollers.

To obtain the iron more pure, or to free it from the carbon with which it is combined in this state, it must be refined by subjecting it to the operations of melting and forging. By the former, in which the metal is kept in fusion for some time, and constantly kneaded and stirred, the quantity of carbon and oxygen it contains are combined, and the produced carbonic acid gas is expelled: the metal at length becomes viscid and stiff; it is then subjected to the action of a very large hammer, or to the more equal, but less forcible pressure of large rollers, by which the remaining oxid of iron, and other impurities not consumed by the fusion, are pressed out. The iron is now no longer granular or crystallized in its texture; it is fibrous, soft, ductile, malleable, and totally infusible. It is termed forged, wrought, or bar-iron, and is the metal in a purer state, though far from being absolutely pure.

REMARK...There are several varieties of this iron arising from the intermixture of other substances. There is one kind of forged iron, which, when cold, possesses ductility; but when heated, is extremely brittle; it is also fusible: this is termed *hot short iron*. Another variety, the *cold short iron*, possesses precisely the opposite properties, being highly ductile while hot, but when cold extremely brittle. The causes of these peculiarities have not perhaps been perfectly explained. Chemists are generally agreed that the property of cold short iron depends on the presence of a substance termed *siderite*, once considered as a peculiar metal, but now known to be a compound of phosphoric acid and iron: that of hot short iron has been ascribed to the intermixture of arsenic, sulphur, or sulphureous acid, but the real cause is not well ascertained.

PROPERTIES OF STEEL.

Steel is of a light grey colour; its fracture is finely granulated, and brilliant, and it is susceptible of a very high polish. It is fusible by itself. It is both ductile and malleable, and when hammered, has a specific gravity greater than that of iron. The property by which it is eminently distinguished is, that of acquiring a degree of hardness by being hastily immersed in cold water when red hot; the hardness being proportioned to the heat of the steel, and the coldness of the water. This is what is termed *tempering* of it, the requisite degree of hardness being given by attending to the degree of heat which the metal acquires, and suffering it to cool accordingly. It may be made so hard as to scratch glass, and at the same time it becomes more brittle and elastic. Steel thus hardened may have its softness and ductility restored to it, by again heating it, and suffering it to cool slowly.

The colours which a polished piece of steel acquires by being heated with access of air, are far brighter than those with which

the other species of iron tarnish in the same situation. It first becomes of a straw-yellow, then of a higher yellow, next purple, then violet, next red, then deep blue, and at last bright blue. At this period it becomes red-hot, and the colours disappear, at the same time that the metallic scales, or the black imperfect oxid of iron which is formed incrust its surface. All these different shades of colour indicate the different tempers the steel has acquired by the increase of heat. Mr. Stodart has availed himself of this property to give to surgical, and other cutting instruments, those degrees of temper which their various uses require, and his attention to this circumstance has rendered his tools so justly celebrated.

Steel possesses a degree of hardness superior to any other metal. It affords sparks with flint. It may be hammered out into much thinner plates than iron, and is more sonorous. It is also possessed of the greatest elasticity, and is perhaps the most useful of all metals.

METHODS OF CONVERTING IRON INTO STEEL.

To form steel, bars of malleable iron are bedded in charcoal in a close furnace, alternate layers of iron and charcoal being formed. A strong fire is applied for six or eight days; the progress of cementation, as this process is termed, is known by drawing a trial bar from the furnace: if this is sufficiently changed the fire is extinguished, and the metal left to cool for some days. This forms *blistered steel*. It is rendered more perfect by subjecting it to the operation of the hammer, as in forging iron; or it is fused, and cast into small bars, forming what is termed *cast steel*. These operations are performed on malleable iron; but those kinds of cast iron which contain little oxygen can be converted into steel by a similar process.

In this operation an increase of weight from $\frac{1}{180}$ th. to $\frac{1}{140}$ th. is gained. The more carbon is introduced the more brittle is the steel. Bergman first showed clearly the presence of this mat-

ter, ascertaining by experiments that less hydrogen gas is disengaged during the solution of steel in diluted sulphuric acid, than during the solution of iron in the same acid; and that during the solution of the steel, carbon is precipitated in the form of plumbago. Morveau has justly observed that it is pure carbon, not its oxid that is present in steel, and to this its great hardness may be ascribed. Bergman further found, that some specimens of steel contained manganese and silex; and Vauquelin has likewise discovered the existence of this earth, and of phosphorus, in several kinds of steel which he analyzed.

CLOUET'S METHOD OF MAKING CAST STEEL.

A new method of preparing cast steel has been lately announced in France by Clouet. His process is the following: Take small pieces of iron and place them in a crucible, with a mixture of carbonate of lime and the earth of Hessian crucibles; six parts of the carbonate of lime and six of this earth must be employed for twenty parts of the iron. The matters are to be so disposed, that after fusion, the iron must be completely covered by them, to prevent it from coming into contact with the external air. The mixture is then to be gradually heated and at last exposed to a heat capable of melting iron. If the fire be well kept up, an hour will generally be sufficient to convert two pounds of iron into excellent and exceedingly hard steel capable of being forged; an advantage not possessed by steel made in the common manner.*

Metallurgy therefore comprehends three arts relative to iron, namely, its first fusion into crude iron; the change of this into bar-iron; and its conversion into steel.

The cause of the difference between crude iron, malleable iron, and steel, consists partly in this; that this metal may still

* Phil. Mag. vol. II. p. 219.

appear in its metallic state though it is slightly oxidated; and partly that it is capable of combining with different quantities of carbon.

Crude iron is not yet absolutely and perfectly de-oxidated or reduced to the complete metallic state: it also holds a considerable portion of carbon in combination, the *grey* containing a greater quantity than the *white* crude iron.

Malleable iron is not only perfectly metallic, but likewise uncontaminated by carbon. It is a simple substance, and if perfectly pure would contain nothing but iron. It however is, strictly speaking, never absolutely pure.

Steel is iron combined with carbon; it has for that reason been called *carbonated iron*. The proportion of carbon has not yet been ascertained with accuracy.

Cast iron, is iron combined with a much larger quantity of carbon than is necessary for forming steel.

METHOD OF DISTINGUISHING IRON FROM STEEL.

Rinman has long ago pointed out a ready method by which steel may be distinguished from iron. When a little diluted nitric acid is dropt upon a plate of steel, allowed to remain for a few minutes, and then washed off, it leaves behind it a black spot; whereas the spot formed by nitric acid upon iron is whitish grey.

RATIONALE...The colour of the black spot is owing to the carbon of the iron, which is converted into charcoal by the acid, and in that state is distinguishable by the eye. Whereas upon iron which is nearly free from carbon this effect cannot take place.

REMARK...This experiment shews that carbon is much more readily oxidated when combined with iron, than when crystallized in the form of diamond.

INFERENCES.

From what has been stated above it is easy to comprehend why good *grey crude iron* is converted into steel by simple fu-

sion either by itself or with the black oxid of manganese, lime, and other such matters. Why it retains the nature of crude iron when fused under charcoal dust. Why by successive ignitions it becomes progressively more ductile and, more difficultly fusible. Why it yields ductile iron if melted with oxid of iron. Why *ductile iron* when fused with and under a stratum of powdered charcoal may be converted either into crude iron or into steel. Why ductile iron becomes steel by cementation with charcoal. Why ductile iron is never changed into steel by mere igniting and forging; and finally, why ductile iron may in some manner assume the nature of steel, if it be smelted with black lead under a cover of powdered charcoal.

The habitudes of the different varieties of iron that have till now occupied our attention are not confined within narrow limits; and for this reason there are innumerable gradations to be met with, beginning from the black crude iron, to the most pure and ductile bar iron.

The knowledge, treatment, and modifications of iron in its different states have great influence on the happiness and power of nations. The perfection of iron-works follows the degree of the civilization of man. Under the form of cast-iron, it serves to construct numbers of machines and utensils. In bar-iron it serves for innumerable purposes: it unites force and resistance to flexibility and spring. In steel it is fitted not only for the grossest purposes of mechanical machinery, but also for those which are the nicest and most delicate, as we see in the instruments of anatomists, engravers, &c. for which uses the other metals, on account of their inferior hardness, cannot be employed. The capability of acquiring the still inexplicable property, called the magnetic power, has given birth to an important instrument, which has opened inexhaustible sources of industry and wealth to nations—the mariners compass; yet in its non-metallic state its uses are many and incalculable. For instance it is capable of yielding the most beautiful colours, Prussian blue, black dyes, &c. In medicine it renders services equally numerous and important.

SECT. II.

EXPERIMENTAL PROOFS

OF

THE PROPERTIES OF IRON.

EXPERIMENT I.

Iron combines with sulphur by heat.

MIX one part of iron filings with two of sulphur, and fuse the mixture in a covered crucible as quickly as possible. The product will be *sulphuret of iron*, which is of a black, or very deep grey colour, brittle, and remarkably hard.

Sulphuret of iron may also be formed by applying a roll of sulphur to the end of an iron bar brought to a white heat; both of them will be fused, and the sulphuret will fall down in drops.

When sulphuret of iron is reduced to powder, and moistened with water, the sulphur is gradually converted into sulphuric acid by absorbing oxygen, while at the same time the iron becomes oxidated. (See vol. I. p. 227).

EXPERIMENT II.

Iron enters into combination with phosphorus.

Mix equal parts of iron filings, and glacial acid of phosphorus, and fuse the mixture in a covered crucible, with half a part of

charcoal powder. A very brittle button will be obtained, white on the fracture, and having a striated and granulated appearance: it sometimes crystallizes in rhomboidal prisms. This is *phosphuret of iron*.

It may also be formed without the interposition of charcoal, by merely fusing together equal parts of glacial acid of phosphorus, and iron filings.

RATIONALE...In the first case the charcoal subtracts the oxygen from the phosphoric acid, and re-converts it into phosphorus, which, in its nascent state, combines with the iron; in the second case part of the iron combines with the oxygen of the phosphoric acid, and becomes vitrified, and the rest forms the phosphuret, which sinks to the bottom of the crucible.

EXPERIMENT III.

Iron decomposes sulphuret of antimony.

Bring five parts of iron filings to a red heat in a crucible, and then introduce sixteen parts of powdered sulphuret of antimony. Expose the mixture to a sudden and strong heat, and the iron will attract the sulphur. When the mixture is thoroughly fused, project, gradually, one part of nitrate of potash in powder, which will greatly facilitate the separation of the scoriae from the antimony. The product will be antimony in its metallic state, which does not contain iron. If, however, one part of iron be made use of with two of sulphuret of antimony, a little iron will remain united with it. This was formerly called *martial regulus*.

EXPERIMENT IV.

Combination of iron with mercury.

Though iron combines with most metals, its union with mercury could not be effected until lately. Mr. Arthur Aikin

succeeded in producing an alloy of iron and mercury.* The method which this gentleman recommends for that purpose consists in uniting an alloy of zinc and mercury with iron filings, and then adding muriate of iron, a decomposition now takes place, and there is produced a muriate of zinc, and an alloy of iron and mercury, which by kneading, and the aid of heat, assumes a metallic lustre.

EXPERIMENT V.

Iron combines with oxygen in two different proportions only.

We have noticed already, (vol. I. p. 191) that iron burns with great splendor and rapidity in oxygen gas, and is at the same time converted into an oxid. But it is capable, by other processes, of combining with two different portions of oxygen, and these oxids are possessed of qualities essentially different from each other. These are the *black*, or the *green*; and the *red*, or the *brown* oxid of iron.

To illustrate this, let a bar of iron be brought to a red-heat; on cooling, its surface will be covered with thin scales, which separate by the blow of a hammer. If this process be continued, the whole bar may be converted into such scales, which are called *forged scales of iron*, or more properly, *black oxid of iron*. This is an *imperfect* oxid of iron; it contains about 27 per cent. of oxygen, and is obedient to the magnet.

If the imperfect oxid of iron, obtained in this process, be reduced to powder, and exposed to a white heat in a crucible, or under a muffle, stirring it frequently, it will become reddish brown. This is the *red*, or *brown oxid of iron*. It is a *perfect* oxid, containing about 48 per cent. of oxygen, and is not affected by the magnet. This oxid, ignited with charcoal, loses part of its oxygen, and becomes re-converted into the black oxid of iron;

* Philosoph. Mag. 1802. No. LII. p. 406.

the same is the case when submitted to the action of sulphurated hydrogen gas.

The black, or green oxid of iron, may also be obtained by keeping iron filings for a length of time in water, at a temperature of about 70° . The oxid thus formed is a black powder, formerly known by the name of *martial ethiops*. It is likewise obtained by making steam pass through a red-hot iron tube, or by burning iron in oxygen gas, or by decomposing a solution of sulphate of iron by the addition of potash, and drying the precipitate expeditiously in a close vessel.

The red, or brown oxid of iron, may also be formed by keeping iron filings red-hot in an open crucible, and agitating them constantly, till they are converted into a dark red powder, formerly called astringent saffron of mars.

It may also be produced by exposing a solution of iron in sulphuric acid, for a long time to the atmosphere; or rather by pouring into it nitric, or oxygenated muriatic acid.

REMARK...We are indebted to Proust for an excellent memoir concerning the combination of oxygen with iron; in which he has illustrated in a very satisfactory manner, that metals are not capable of indefinite degrees of oxidation, but only of a certain number, and that every particular oxid consists of a determinate quantity of the metal, and oxygen chemically combined.

The metal under consideration for instance, is not capable, as was formerly supposed, of uniting with oxygen in all the intermediate degrees, between 0.27, and 0.48.

It can only combine with, *precisely*, 0.27 parts, or 0.48 parts, and *with no other proportion*; and therefore is only capable of forming the two oxids considered before.

To talk therefore of oxidating a metal indefinitely is not accurate, except it be intended to signify the combining of part of it with oxygen, while the rest remains in its natural state.

If, therefore, iron be oxidated at all, it *must be* combined with 0.27 of oxygen; if it be oxidated more than this, it must be combined with 0.48 of oxygen.

In like manner every other metal, as we have seen already, combines with certain proportions of oxygen, and forms either two or more oxids, according to its nature.

Whenever metals are capable of forming more than one oxid, it is only the first oxid, or that which contains a *minimum* of oxygen, which is formed by the direct combination of oxygen with the metal, for oxygen is capable of uniting with metals, or with any other substance for which it has an affinity, only in *one* determinate proportion.

Iron, for instance, and oxygen can only combine in the proportion of 73 parts of iron, and 27 of oxygen. These two quantities saturate each other, and form a compound which is incapable of receiving into it any more oxygen or iron: this compound is the *black or green oxid of iron*.

How comes it then, it will be asked, that there is another oxid of iron, the *brown, or red oxid*, which contains 52 parts of iron, and 48 of oxygen, proportions certainly very different from 73 and 27? Because there is an affinity between the green and black oxid of iron and oxygen. They are capable of combining together, and of saturating each other in the proportion of about 71.5 parts of black oxid, and 28.5 of oxygen, and the compound which they form is the *brown, or red oxid*, which of course contains 52 parts of iron, and 48 of oxygen: But then it is not formed by the combination of these two substances directly, but by the combination of the black oxid and oxygen. In like manner lead and oxygen combined form grey oxid of lead, (page 110); grey oxid of lead and oxygen combined form white oxid; white oxid of lead and oxygen combined form red oxid; which last oxid, when combined with oxygen, forms the brown oxid of lead.

That this is the case, cannot be doubted, if we consider that, in general, every one of these successive doses of oxygen is retained by a weaker affinity than the dose which precedes it. Thus the brown oxid of iron is composed of iron, and two doses

of oxygen. The first dose amounts to 0.37, the second to 0.56 of the iron. Consequently,

Iron. Oxygen. Black oxid.

$$1 + 0.37 = 1.37 \quad \text{Oxygen. Brown oxid.}$$

$$1.37 + 0.56 = 1.93.$$

If the second dose of oxygen be abstracted, there will remain behind 1.37 of black oxid. If both doses be abstracted, there will remain behind 1 of pure iron. If both these doses adhere to the iron with the same force, it is obvious that every substance which is capable of abstracting one of these doses would be capable also of abstracting both, provided it be employed in sufficient quantity. But it is a fact that many substances are capable of abstracting the second dose of oxygen, which have no action on the first dose.

If hidrogen gas, for instance, be made to pass through brown oxid of iron, heated to redness in a porcelain tube, it converts it into black oxid of iron, and consequently deprives the iron of its second dose of oxygen. But it produces no change upon the black oxid in similar circumstances. Hidrogen gas is therefore capable of depriving iron of its second dose of oxygen only.

These observations apply equally to the oxids of other metals. The subject is of the highest importance, and must be more fully investigated before the action of the metals and their oxids upon oxygen and upon each other can be understood.

For if equal parts of iron, and the red oxid of iron, are heated together, the whole is converted into the black oxid. This is the case, because the iron having a stronger affinity for oxygen than that of the red oxid for its second dose, the oxid is deprived of that quantity of its oxygen, and they are both converted into iron, oxidated at its *minimum* or black oxid of iron; but whence arises a sufficiency of oxygen to oxidate the whole of the iron?

If we suppose 193 parts of red oxid, and 193 parts of iron to be heated together: 193 parts of red oxid are composed of 137 black oxid + 56 oxygen: 193 parts of iron, to be converted into black oxid, require 71 parts of oxygen; but the second dose, which they can alone attract, consists of only 56 parts, consequently 15 parts of oxygen are wanting. This small portion must either be supplied by the atmosphere, or 55 parts of the iron must remain uncombined with oxygen.*

ANALYSIS OF ORES OF IRON.

As to the manner of assaying iron ores, for the purpose of making a calculation of the quantity of metal which may be extracted from the ore, if to be wrought on a large scale, the following methods have been found to answer the end very accurately:

A certain quantity of the ore which is to be assayed, is first reduced to small particles, and torrefied by a gentle heat, not stronger than is required to separate the moisture, and to volatilize the sulphur, if the ore contains any, which is easily perceived by the smell during the torrefaction. When the moisture and sulphur are separated, four parts of the remaining ore is to be mixed with an equal quantity of common salt, or *muriate of soda* (*which has been previously deprived of its water of crystallization by stirring it in a flat earthen vessel over fire*) and with the same quantity of a mixture of equal parts of fluor spar and lime, and half a part of charcoal. This mixture is kept red hot in a crucible covered with charcoal, for $\frac{3}{4}$ of an hour, after which the iron contained in that quantity of ore is found in a metallic state in the bottom of the crucible.

Or, four hundred grains of sub-borate of soda, 40 grains of slacked lime, and 200 grains of the ore to be assayed, are mixed

* This is a proof that the proportions of oxygen in the oxids are not yet accurately ascertained. Indeed, from the very nature of the experiments, nothing but approximations can be expected.

together. The mixture is pulverized, and placed in a lined crucible, which is to be covered. The heat of a forge-furnace is then sufficient to effect the reduction of the metal, which is generally done in the course of half an hour.

The moist or humid way of assaying the ores of iron, is attended with more difficulty. The following method is the most simple: A certain quantity of iron ore is reduced to powder, and digested with about six parts of muriatic acid, which takes up the iron, and such earths as are soluble in that acid, and leaves the silex and the sulphur behind; after which, the solution is to be saturated with potash, (or if the ore contains any copper, with ammonia) which precipitates the iron in the state of an *oxid*, along with the dissolved earths; the precipitate is then well dried, and strongly heated to redness, after which, it is pulverized, and put in digestion with diluted nitric acid, which then takes up all the earths, together with the other heterogeneous substances, and leaves the iron behind, which, on account of its being so highly oxidated, loses its solubility in that acid; it is then well washed, freed from the acid, and afterwards recovered by charcoal, or any other inflammable matter which has a stronger affinity to the oxygen than the iron; the metal found in the bottom of the crucible, indicates the proportion of the metal contained in a given quantity of the ore.

Arseniate of iron was analyzed by Mr. Chenevix in the following manner: One hundred parts of it were boiled with potash till the arsenic acid was separated. Nitrate of lead was mixed with the solution; 100 parts of the precipitate indicated 33 of arsenic acid. That portion of the ore which eluded the action of the potash was treated with muriatic acid; the undissolved residuum was silex. The muriatic acid was super-saturated with ammonia. The iron precipitated; but the copper was dissolved by the ammonia.*

* Phil. Trans. 1801, p. 219.

COPPER.

PART LII.

SECT. I.

NATURAL HISTORY OF COPPER.

COPPER is found in the earth in various states. It is found native, (*native copper*) possessing the red colour, malleability, and many of its other properties; it is however not quite pure, but generally mixed with a minute portion of gold or silver.

This ore is found of an indeterminate figure, in solid and compact masses; sometimes in plates and threads, which assume a variety of forms. It crystallizes in cubes. It then is flexible. It has much metallic lustre. It is found in many parts of Europe.

Copper ores are very numerous. Copper combined with oxygen forms *oxid of copper*, or the *earthy copper ore*, (*mountain blue*.) United to carbonic acid it constitutes the hepatic copper ores, (*mountain green*,) &c. The compact ore of this kind is termed *malachite*.

This ore generally exhibits a very fine grass-green, emerald-green, or apple-green colour. It is found in solid masses of an indeterminate shape. It has often a beautiful satin-like appearance, or silky lustre.

It also exists mineralized by the muriatic acid, sulphuric acid, arsenic acid, &c. Copper mineralized with sulphur is called *vitreous copper ore*. Its colour is generally lead-grey. Combined with sulphur and iron it forms the *azure copper ore* and all the varieties of copper pyrites. Mineralized with sulphur, arsenic, iron, and zinc, it constitutes the *brown* or *blendose copper ores*, of which there are many varieties. Copper mines are abundant in Britain, Germany, &c.

PROPERTIES OF COPPER.

Pure copper is of a rose-red colour, very sonorous, very tenacious, ductile, and malleable; of a considerable compactness; moderately hard and elastic. Its texture is granulated, and subject to blisters. It crystallizes in quadrilateral pyramids. Its specific gravity is between 7.788 and 8.594. When rubbed it emits a disagreeable odour. It melts at 27° of Wedgwood's pyrometer. At a higher temperature it burns with a beautiful green flame. It is a good conductor of caloric, of electricity, and of galvanism. Exposed to the air it becomes brown and at last green by absorbing carbonic acid. When heated it turns blue, yellow, violet and brown. It readily fuses with phosphorus and unites to sulphur when finely divided by mere trituration. It does not decompose water at the temperature of ignition. It is acted on by the greater number of the acids. Nitric acid acts on copper with great vehemence. Sulphuret of potash combines with it in the dry and in the humid way. It is capable of alloying with the greater number of the metals. With zinc it forms the compound metals called brass, pinchbeck and others: with tin it forms bell-metal and bronze. It unites to the earths

merely in vitrification. Liquid ammonia causes it to oxidate quickly when air is admitted. It decomposes muriate of ammonia and red sulphurated oxid of mercury by heat. It is poisonous to the human constitution.

METHOD OF OBTAINING COPPER.

Copper is procured from its ores by different processes according to the nature of those ores. If they contain much sulphur, after being pounded and washed, they are roasted in the open air to dispel the sulphur. The ore is afterwards roasted once or twice more, and is melted in an open fire into a mass, called a mat of copper. In this state it still contains a large quantity of sulphur, which the workmen continue to expel by repeated roastings and fusion, till the metal acquires a certain degree of purity, and is called black copper, which is somewhat malleable, but still contains sulphur, iron, and in general some other impurities. In order to get entirely rid of these, the copper is hastily fused with three times its weight of lead. The lead unites with the copper and expels the iron; and the rest of the metals which happen to be mixed with the copper are thus expelled. The copper is afterwards refined by keeping it heated in crucibles for a considerable time, so that it may throw up all the foreign substances it still contains in the form of scoriae. It is examined from time to time by immersing iron rods into it, which become coloured with a small quantity of copper, and its purity is judged of by the brilliant redness of these specimens.

SECT. II.

EXPERIMENTAL PROOFS
OF
THE PROPERTIES OF COPPER.

EXPERIMENT I.

Copper dissolves readily in diluted nitric acid.

(Preparation of nitrate of copper.)

LET copper filings be dissolved in a sufficient quantity of nitric acid of a moderate strength; when no further effervescence ensues boil the acid gently upon the copper, until a pellicle appears. Decant the solution and evaporate it slowly, and when a strong pellicle is formed suffer it to crystallize. The salt thus obtained is of a fine blue colour.

EXPERIMENT II.

Action of liquid ammonia on copper.

A singular phenomenon which attends the action of liquid ammonia on copper has long attracted the notice of chemists.

If a bottle, provided with a ground stopper, be filled quite full of liquid ammonia, and some copper filings be introduced,

and the bottle immediately stopped without including any air, no solution will take place. On the contrary, if the bottle be left open for some time, and then closed, a solution is effected, which is absolutely colourless, but turns blue on re-opening the bottle, beginning at the surface and gradually extending downwards through the whole mass. Again, if this blue solution has not been too long exposed to the air, and fresh copper filings be put in, stopping the bottle again, the solution is deprived of all its tinge, and recovers its colour only by the admission of air. And this effect may be produced repeatedly.

RATIONALE...Metallic copper, as such, is not acted upon by liquid ammonia, but is soluble when oxidated. This oxidation is effected by the influence of oxygen gas when atmospheric air is admitted. Hence, when the copper is no farther oxidated than is necessary for solution, this is colourless; but it acquires a blue colour when the metal is oxidated in a higher degree. It is also obvious that this azure colour is again destroyed by the addition of more copper filings and exclusion of air, as the newly added metal deprives that which was contained in the solution in an oxidated state of its super-abundance of oxygen in order to be dissolved also in the liquid.

EXPERIMENT III.

Copper combines with phosphorus.

(Preparation of phosphuret of copper.)

Mix together equal parts of fine copper filings and glacial acid of phosphorus, add one-eighth part of charcoal-powder, and then fuse the whole in a Hessian crucible. The product will be a metallic button of a whitish appearance, which sometimes exhibits the prismatic colours.

EXPERIMENT IV.

Copper combines with sulphur both in the wet and in the dry way.

(Preparation of sulphuret of copper.)

Take equal quantities of copper filings and sulphur, and having formed them into a soft paste, by the addition of a sufficient quantity of water, expose the mixture to the air; lixivate it at the end of some days, and sulphate of copper will be obtained by crystallizing the lixivium.

A sulphuret of copper may be obtained by putting into a crucible alternate strata of thin plates of copper and sulphur in powder. The crucible is then to be exposed to a gradual heat, in a furnace, till no more vapours issue from it. Keep the crucible in a dull red heat for an hour, and then suffer it to cool. The product will be a sort of copper slag, brittle, and of an iron colour, which when worked exhibits the colour of green oxid of copper.

EXPERIMENT V.

Copper unites readily with zinc, and forms a compound, called brass.

Brass is produced by the following processes: Put into a crucible four parts of granulated copper and twelve of zinc, and nearly fill the crucible with charcoal-powder, cover it and bring it briskly to a red heat, the copper will unite with the zinc and form brass.

If plates of copper be cemented with native oxid of zinc reduced to powder, and mixt with charcoal also in powder, by bringing the mixture to a red heat in a covered crucible, the copper and zinc will unite and likewise form brass.

Brass is made in the large way by a process similar to this.

Tombac is obtained in a like manner by fusing together in a crucible twelve parts of copper and three of zinc.

Gun-metal is said to consist of copper alloyed with one tenth part of tin.

Bell-metal is copper alloyed with about one-sixth of tin; it may in general be observed that a less proportion of tin is used for making church-bells than clock-bells, and that a little zinc is added for the bells of repeating watches, and other small bells.

The metal of which *cocks* are in general made is copper alloyed with zinc and lead.

EXPERIMENT VI.

Concentrated sulphuric acid only acts upon copper at elevated temperatures.

Pour upon one ounce of copper filings in a matrass, two ounces of concentrated sulphuric acid, there will be no action in the cold; but if the matrass be placed on a sand-bath, and a degree of heat applied nearly sufficient to make the acid boil, the copper will be gradually dissolved and sulphureous acid gas will be liberated.

EXPERIMENT VII.

Copper unites with arsenic acid, and forms a compound, called Scheele's green.

This colour is formed by decomposing sulphate of copper by the arseniate of potash, in the following manner:

Dissolve potash in water with heat; add white oxid of arsenic or arsenic acid to the point of saturation, and filter the liquor.

Then take a warm solution of sulphate of copper and pour it into the arseniate of potash; a little only must be added at a time, and it must be continually stirred with a glass rod. Leave the mixture at rest till a precipitate is formed; then decant the liquor, and having washed the residuum repeatedly in warm water, filter it and leave it to dry. By this process a beautiful green colour is obtained.

As this colour is not alterable by air, it is employed in painting.

EXPERIMENT VIII.

Preparation of blue verditer.

To a solution of nitrate of copper, add pulverized lime, and shake the mixture to facilitate the decomposition. A little excess of nitrate of copper should be used, that the whole of the lime may be saturated, and that the precipitation formed at the moment of mixture may be a pure precipitation of copper; the precipitate is suffered to settle, after which the super-natant fluid is decanted, and the residuum being repeatedly washed, is deposited on a piece of cloth to drain.

It is from this precipitate, which is of a delicate green colour, that the blue verditer is prepared.

For this purpose grind it on a colour-stone or in a large mortar with a little quick-lime. This mixture acquires, in a moment, by trituration a very lively blue colour. The quantity of lime necessary is about four or five per cent. of the precipitate.

If the precipitate is too dry, add a very small quantity of water, in order that the mixture may form a paste somewhat liquid, and easy to be pounded.

The whole must be afterwards dried.

REMARK...There are two kinds of verditer in the market; the one, called *refiners verditer*, has the form of a very soft, impalpable powder, and possesses a stronger body of colour than the other, which is in harsh, irregular lumps, not easily diffusible in water.

The best verditer is at present made only by the refiners, they obtain the nitrous solution of copper at a cheap rate during the process of parting; the value of the article not admitting of the direct application of nitrous acid to copper. The common verditer is made by decomposing sulphate of copper by means of lime. A comparative analysis of both articles has shown that the verditer obtained in this manner is always contaminated with a considerable quantity of oxid of iron and sulphate of lime; both admixtures arising probably from the impurity of the sulphate of copper employed, and the difficult solubility of the sulphate of lime formed in the process. These objects are well worthy of being attended to, for the article is of considerable commercial importance.

ANALYSIS OF ORES OF COPPER.

In order to analyze *sulphuret of copper*, let one part of the ore, reduced to powder, be digested, or extracted, with three or four of nitric acid by heat, as long as it will take up any of the ore; then filter the whole, and wash the insoluble residue, which for the greatest part consists of sulphur. Its quantity may be ascertained by subliming it by heat, or by burning it in the open air. It becomes thus partly converted into sulphuric acid. The residue may be diluted with water, and then decomposed by the addition of nitrate of barytes. The insoluble precipitate, when dry, contains 14.5 of sulphur.

In order to separate the iron, let the solution be boiled down to dryness, re-dissolved in nitric acid, and evaporated to dryness again repeatedly, the iron will then be separated in the form of a red oxid when water is added to the solution. To ascertain the quantity of copper which was contained in the ore, the solution from which the iron is separated must be decomposed by the addition of a solution of potash. The precipitate, after being dried in a red heat, is black oxid of copper. One hundred parts of it contain 80 of metallic copper.

Red copper ore may be dissolved in muriatic acid, and then immersing into this solution polished plates of iron, so long as a film of copper is precipitated upon them. 88 parts of the precipitated copper being equivalent to 100 of the oxid of which the ore is composed.

Arseniate of copper was analyzed by Chenevix * in the following manner :

The ore was dissolved in diluted nitric acid, and then decomposed by nitrate of lead. The solution was evaporated till a precipitate began to appear, and then mingled with alcohol. The product which became precipitated was arseniate of lead; 100 parts of which indicate 33 of arsenic acid. The copper must then be separated from the nitric acid by boiling it with potash as directed above.

Native copper sometimes contains gold, silver, or iron. If the ore therefore be dissolved in nitric acid, the gold will not be acted upon by this acid, but the other metals will be dissolved. The silver may be separated by immersing into the solution a polished plate of copper, (or it may be precipitated from a separate portion of the solution by muriatic acid, or common salt); the iron may be separated by boiling the solution to dryness, and treating the residuum with water. By this process the nitrate of iron is decomposed; the oxid of iron remains while the water dissolves the nitrate of copper. This nitrate may be decomposed by boiling it with potash, and its quantity of metal estimated as stated above.

In order to obtain pure copper, let the copper of commerce be dissolved in muriatic acid, and precipitate it by a polished plate of iron; or the black oxid of copper obtained by decomposing cuprated ammonia may be melted with its own weight of pounded glass and pitch.

* Philosoph. Trans. 1801, p. 195.

*Class V....*EXCEEDINGLY DUCTILE AND DIFFICULTLY
OXIDABLE METALS.

SILVER.

PART LIII.

SECT. I.

NATURAL HISTORY OF SILVER.

THIS metal is found both native and mineralized, and combined with lead, copper, mercury, cobalt, sulphur, arsenic, &c. The principal ores of this metal are the following: Native silver, antimoniated silver, sulphuret of silver, sulphurated oxid of silver and antimony, muriate of silver, native oxid of silver, &c. It is found in different parts of the earth. The mines of the Erzgebürge or the metalliferous rocks of Mexico and Potosi, Bohemia, Norway, Transylvania, &c. are the richest.

Native silver possesses all the properties of this metal, and it appears in series of octahedra inserted in one another; in small capillary flexible threads intertwined together; in plates; or in

masses. The colour of native silver is white, often tarnished. Silver alloyed with gold forms the *auriferous native silver ore*. The colour of this ore is a yellowish white. It has much metallic lustre. The *antimoniated silver ore* belongs to this class. Silver combined with sulphur, forms the *sulphurated oxid of silver*, or *vitreous silver ore*. This ore occurs in masses, sometimes in threads, and sometimes crystallized in cubes or regular octahedra. Its colour is dark bluish grey, inclining to black. Its fracture is uneven, and its lustre metallic. It is soft enough to be cut with a knife. It is sometimes found alloyed with antimony (grey silver ore.) Silver united to muriatic acid forms the *corneous silver ore* (*muriate of silver*,) which appears under different colours and shapes. Silver united to oxygen constitutes the *calciiform silver ore*, of which there are several varieties. The colour of these ores is a lead-grey, or greyish black. They occur massive, disseminated, and crystallized.

Germany, and other countries of Europe, but more especially Peru and Mexico in South America, contain the principal silver mines. There are, however, silver mines in Ireland, Norway, France, and many other parts of the world.

PROPERTIES OF SILVER.

Pure silver is very brilliant, white and sonorous. It is the most splendid of all the metals. Its specific gravity is from 10.474 to 11.091 according to the state of its density. It is exceedingly ductile and tenacious. It may be beat out into leaves only $\frac{1}{160000}$ part of an inch thick, and drawn into wire the thousandth part of an inch thick. It melts at 26° of Wedgwood's pyrometer. Exposed to a temperature considerably higher it becomes volatilized. Atmospheric air has no effect upon it except when it contains sulphureous vapours, sulphurated or phosphorated hidrogen gases. It unites to phosphorus and sulphur. It slightly unites with the brittle acidifiable metals;

but it readily enters into combination with the greater number of the other metals. With gold it forms what is termed *green gold*. Copper renders it harder without much impairing its ductility. Mercury and silver combine and form a crystallizable and fusible alloy. It unites with the rest of the metals except cobalt and nickel. It is oxidated and dissolved by several of the acids. The nitric acid attacks it rapidly in the cold. The sulphuric acid requires a boiling heat. The muriatic acid does not act upon it. The acid solutions of silver are decomposable by the alkalies, earths, and by the greater number of the metals.

METHOD OF OBTAINING SILVER.

Different methods are employed in different countries to extract silver from its ores. In Mexico, Peru, &c. the mineral is pounded, roasted, washed, and then triturated with mercury in vessels filled with water. A mill is employed to keep the whole in agitation. The silver combines by that means with the mercury. The alloy thus obtained is afterwards washed, to separate any foreign matters from it, and then strained and pressed through leather. This being done heat is applied to drive off the mercury from the silver, which is then melted and cast into bars or ingots.

In order to extract silver from sulphurated or vitreous silver ore, the mineral is roasted, and then melted with lead and borax, or some other flux to assist the fusion. By the first operation the sulphur is volatilized, and by the second the silver is obtained, though for the most part alloyed with the other metals, from which it is separated by cupellation, or fusion with lead or bismuth.

SECT. II.

EXPERIMENTAL PROOFS
OF
THE PROPERTIES OF SILVER.

EXPERIMENT I.

Silver unites to phosphorus by fusion.

(Phosphuret of silver.)

MIX two parts of glacial acid of phosphorus and one of silver filings, with half a part of charcoal dust; introduce the mixture into a crucible, placed in a forge or furnace, and expose it to a red heat for about an hour.

When the fusion is complete, the silver appears at the bottom of the crucible in the middle of the fused acid and small jets of phosphorus project themselves from it; remove the crucible into the open air and the metal will speedily cease to be fluid. The button obtained is *phosphuret of silver*, from which the phosphorus may be again separated by heat, leaving the silver very pure.

EXPERIMENT II.

Silver unites to sulphur.

(Sulphuret of silver.)

Put plates of silver and sulphur reduced to powder into a crucible, in alternate strata, beginning with a stratum of sulphur,

and finishing with the silver; cover the crucible, place it among burning coals and bring it to a red heat as speedily as possible. The two substances will thus be combined, and the result is a mass of a dark violet colour, much more fusible than silver, brittle and disposed in needles. This is *sulphuret of silver*.

EXPERIMENT III.

Silver enters into combination with sulphuret of potash in the dry way.

Fuse together, in a crucible, one part of silver and four of sulphuret of potash; stir the mixture frequently and when it is well fused, pour it on a smooth stone, which has been rubbed with a little grease.

This compound is soluble in water and the combination of the silver with the sulphuret is so intimate that it will pass through bibulous paper.

EXPERIMENT IV.

Silver unites to mercury with great facility.

Triturate in a marble mortar, one part of silver leaf and seven of mercury; the product will be an alloy which has but little consistence.

A similar combination may be effected by using silver filings; but in that case the trituration must be made in a warm mortar.

REMARKS... This amalgam assumes a regular form by fusion and cooling slowly.

The mercury acquires a degree of fixity in this sort of combination; for it requires a much greater heat to separate it from the silver, than is necessary to volatilize it alone.

EXPERIMENT V.

Silver decomposes concentrated sulphuric acid, at a boiling heat.

Put one part of silver filings into a retort, pour over it six of concentrated sulphuric acid and heat the mixture over a lamp; the acid will be decomposed and sulphureous acid gas will be obtained. The residue in the retort is *sulphate of silver*, which by solution in a large quantity of boiling water, and evaporation, may be obtained in the form of small needle-shaped crystals.

EXPERIMENT VI.

Silver is dissolved by nitric acid, with great rapidity.

Pour nitric acid of a moderate strength, upon some silver in a Florence flask; an effervescence will take place, the metal will be dissolved and nitrous gas will be liberated copiously. If both the silver and acid were perfectly pure, the solution will be colourless, but if otherwise, it will have a milky or greenish hue. If the solution be evaporated it shoots into tabular or scaly crystals, called *nitrate of silver*.

REMARK...A solution of nitrate of silver, stains animal and vegetable substances a deep black; and the colour produced is exceedingly permanent, hence it has been applied for the staining of human hair; but when thus made use of, it should be very much diluted, and used with great caution, on account of its corrosive property.

The article known by the name of *indelible, or permanent, marking ink* for marking linen, wearing apparel, &c. consists of a solution of nitrate of silver, thickened with a little gum arabic.

The fluid known by the name of *silver-test*, for detecting counterfeit silver coin is a solution of standard silver considerably diluted.

EXPERIMENT VII.

Muriatic acid does not attack silver, but separates it from its solution.

Let fall some muriatic acid into a solution of nitrate of silver, a white curdy precipitate will be instantly formed in great abundance. This precipitate is decomposed by light, for if it be exposed to the direct rays of the sun, the white colour will be changed to brown and afterwards to black. If fused by a gentle heat it forms a semi-transparent mass of the consistency of horn; hence it was formerly called *horn-silver*, but now more properly *muriate of silver*.

REMARK...To reduce muriate of silver, let one part of it be mixt with three of soda, and exposed to a white heat. When the mixture is well fused, suffer it to cool; then break the crucible, and separate the silver from the muriate of soda which has been formed. The silver obtained by this means is exceedingly pure.

EXPERIMENT VIII.

Preparation of ammoniated oxid of silver.

(Berthollet's fulminating silver.)

Dissolve fine silver in pale nitric acid and precipitate the solution by lime water; decant the fluid; mix the precipitate with liquid ammonia and stir it till it assumes a black colour; then decant the super-natant fluid and leave it in the open air to dry. This product is fulminating silver, invented by Berthollet, which when once obtained *cannot be touched* without producing a violent explosion. It is the most dangerous preparation known; for the contact of fire is not necessary to cause it to detonate. It explodes by the mere touch of any substance. Its very pre-

paration is so hazardous, that it is not to be safely attempted without a mask with strong glass eyes upon the face. No more than a single grain will admit of exhibiting its effect, and even that quantity must be approached with caution. A larger portion cannot be exploded without imminent danger.

RATIONALE....The detonation of this compound is to be ascribed to the hydrogen of the ammonia suddenly combining with the oxygen of the metallic oxid, and forming aqueous vapour, which is disengaged with the nitrogen gas; the elasticity of both the gases is augmented by the caloric which is disengaged. No explanation has yet been given why its force is so much greater than that of fulminating gold; but it is probably owing to the silver when in the state of an oxid containing more oxygen than the gold, and to this oxid combining with a larger portion of ammonia; hence, in the sudden combination, more aqueous vapour and nitrogen gas will be disengaged.

REMARK...If the fluid which is separated from the precipitate be slowly evaporated, crystals are formed which explode more violently than the precipitate; a few grains of them cannot be touched without hazard of life.

EXPERIMENT IX.

Preparation of hyper-oxygenated muriate of silver.

(Chenevix's fulminating silver.)

Mr. Chenevix has lately invented a fulminating silver which is more safe than the former; for it explodes only by a slight friction in contact with combustible bodies. It may be prepared in the following manner:

Diffuse a quantity of alumine through water, and let a current of oxygenated muriatic acid gas pass through it for some time. Then digest some phosphate of silver (obtained by pouring a solution of phosphate of soda into a solution of nitrate

of silver) on the solution of the oxygenated muriate of alumine, and evaporate it slowly. The product obtained will be a hyper-oxygenated muriate of silver; a single grain of which, in contact with two or three of sulphur, will explode violently by the slightest friction.

EXPERIMENT X.

Arbor Dianæ.

Most metallic substances are capable of decomposing a nitric solution of silver. The separation of this metal by mercury, on account of the phenomena which it presents has been called Diana's tree, or *Arbor Dianæ*.

According to Lemery, dissolve one part of fine silver in weak nitric acid to saturation, and, having diluted this solution with about twenty parts of distilled water, add two parts of mercury.

Homburg's method is to make an alloy in the cold, of four parts of silver-leaf and two parts of mercury; to dissolve this alloy in a sufficient quantity of nitric acid, and to add to the solution distilled water.

If we put into this liquor a small ball of a soft alloy of silver, a precipitation of the silver immediately takes place.

Baumé gives the following process, which will be attended with more success:

Mix together six parts of a solution of silver and four of a solution of mercury, both made with the nitric acid, and completely saturated; add to them a little distilled water, and put the mixture into a conical vessel, into which have been previously introduced six parts of an alloy made of seven parts of mercury and one of silver.

At the end of some hours there will be formed, at the surface of the small mass of alloy, a vegetation in the form of a bush.

A process which succeeds better than any of the former, is to dissolve three drachms and 48 grains of pure silver and half as much mercury, separately, in a sufficient quantity of pure nitric

acid. Mix the solutions, and add to them five or six ounces of distilled water. This must be poured upon seven drachms and 12 grains of an amalgam of silver of the consistence of butter, which had been previously put into a spherical vessel of white glass. The vessel must be kept undisturbed, and in about 24 hours a very beautiful silver-tree will be formed.

RATIONALE...The mercury contained in the solution attracts that of the amalgam; the silver contained in the latter acts also on that which is held in solution; and the result of these attractions is a speedier precipitation of the silver. The mercury, which makes part of the amalgam, being more abundant than would be necessary for precipitating the silver of the solution, produces also a third effect, which is, that it attracts the silver by the affinity and tendency it has to combine itself with that metal.

REMARK...In order to obtain a beautiful vegetation, it is absolutely necessary that all the ingredients be of the utmost purity. A cylindrical or conical glass vessel is best suited for it.

EXPERIMENT XI.

Precipitation of silver by copper.

(Vegetation of silver on glass, slate, &c.)

Spread a few drops of a solution of silver in nitric acid, upon a smooth piece of slate, or on a plate of glass, by means of a camel's-hair-pencil or feather; place at the bottom of it, in contact with the fluid, a copper or brass wire of about one sixteenth of an inch in diameter, and let the whole remain undisturbed in a horizontal position: in a short period of time it will begin to vegetate. Then with a pencil draw a fluid stroke to any part of the glass or slate, in order to represent the body of a tree, and

at the bottom a stroke may be drawn for the ground. Having done this, scatter a few clean brass filings over the whole.

If on the plate of glass is carefully placed another plate of copper or brass, and held in a clear coal fire, till it becomes red hot, the whole will appear to be converted into a golden metallic vegetation. Under a glass magnifier, or microscope, this vegetation appears in a beautiful manner.

RATIONALE... This phenomenon like the former, is produced by the attraction of the copper or brass, for nitric acid being stronger than that of the silver: the latter losing its oxygen returns to the metallic state.

SILVERING.

There are various methods of giving a covering of silver to the surfaces of bodies. For instance,

Copper may be silvered over, by rubbing it with the following powder: Two drachms of acidulous tartarite of potash, the same quantity of muriate of soda, and half a drachm of sulphate of alumine, mixed with fifteen or twenty grains of silver, precipitated from nitrate of silver by copper. The surface of the copper becomes white when rubbed with this powder, which may afterwards be brushed off, and polished with leather.

The sadlers and harness makers cover their wares with tin for ordinary uses, (as stated before, page 105) but a cheap silvering is used for this purpose as follows: Half an ounce of silver that has been precipitated from nitrate of silver by the addition of copper; muriate of soda, and muriate of ammonia, of each two ounces, and one drachm of muriate of mercury are triturated together, and made into a paste with water; with this, copper utensils of every kind, that have been previously boiled with acidulous tartarite of potash, and sulphate of alumine, are rubbed, after which they are made red hot and then polished. The intention of this process appears to be little more than to apply the silver

in a state of minute division to the clean surface of the copper, and afterwards to fix it there by fusion; and accordingly this silvering may be effected by using the argentine precipitate here mentioned with supersaturated borate of soda, or mercury, and causing it to adhere by fusion.

The dial plates of clocks, the scales of barometers and other similar articles are silvered by rubbing upon them a mixture of muriate of silver, muriate of soda, and acidulous tartrate of potash, and afterwards carefully washing off the saline matter with water. In this operation the silver is precipitated from the muriatic acid, which unites with part of the coppery surface. It is not durable, but may be improved by heating the article, and repeating the operation till the covering seems sufficiently thick.

Shell-silver for the use of painters is prepared by triturating silver-leaf with a little honey or mucilage of gum arabic in a mortar; and afterwards separating the honey or gum by means of water. When the honey or gum is washed away the silver may be put on paper or kept in shells, whence its name. When it is to be used it must again be diluted with gum-water.

REMARK...The application of silver-leaf for silvering paper, wood, &c. is analogous to the application of gold-leaf which will be noticed circumstantially in the next part.

PLATING.

The covering of the surface of copper with silver or plating is performed in the following manner: Upon small ingots of copper, plates of silver are bound with iron wire, generally allowing one ounce of silver to twelve ounces of copper. The surface of the plate of silver is not quite so large as that of the copper ingot. Upon the edges of the copper which are not covered by the silver, a little borax is put, and by exposing the whole to a strong heat, the borax melts, and in melting contributes to fuse that part of the silver to which it is contiguous, and to attach it in that state to the copper. The ingot, with its silver

plate, is then rolled under steel rollers, moved by machinery, till it is of a certain thickness; it is afterwards cut to a greater or less extremity according to the use for which it is intended.

An ounce of silver is often rolled out into a surface of about three square feet, and its thickness is about the three thousandth part of an inch; and hence we need not wonder at the silver being soon worn off from the sharp edges of plated copper, when it is rolled to so great an extent.

REMARK...What is commonly called French plate, is not to be confounded with plated copper. French plate is made by heating copper, or more commonly brass, to a certain degree; silver leaf is then applied upon the heated metal, to which it adheres by being rubbed with a proper burnisher.

ANALYSIS OF ORES OF SILVER.

The analysis of the ores of silver has been always considered as very important, on account of the great value of the metal which they contain in abundance.

The ore, called *native silver*, is to be dissolved in nitric acid. The gold, if the ore contains any, remains in the state of a black powder, and may be dried and weighed. The silver may then be precipitated, by adding to the solution common salt. Every hundred parts of the dried precipitate, denote about 75 parts of silver. But, as lead may be present in the solution, and this metal is also precipitated by the muriatic acid of the common salt, it may be proper to immerse in the solution which should not have an excess of acid a polished plate of copper. This will precipitate the silver in a metallic form. The muriate of silver is soluble in liquid ammonia, but that of lead is not. The presence of copper may be ascertained by the green colour of the solution, and by the blue colour which it assumes on adding to it ammonia. The copper may be precipitated by immers-

ing into it a plate of iron. When the ore contains arsenic, its proportion may be estimated by weighing before and after fusion; for the arsenic is dissipated by heat: or the ore may be dissolved as before in nitric acid, which acidifies the arsenic. After the separation of the silver, the arsenic acid may be precipitated by the nitrate of lead, 100 parts of the dry precipitate indicating about 22 of arsenic.

Sulphuret of silver is to be treated with diluted nitric acid, which dissolves the silver, leaving the greater part of the sulphur untouched. The residuum is to be dried, and then the sulphur burnt off. The loss of weight gives the sulphur. The silver is to be precipitated by common salt; and the other metals, if any be present, may be ascertained as above. Part of the sulphur is always acidified. The acid thus formed may be precipitated by nitrate of barytes, 100 parts of the dried precipitate indicating about 14.5 of sulphur.

Antimoniated silver ore was analyzed by Klaproth in the following manner: 100 parts of it were boiled in diluted nitric acid. The residuum, washed and dried, was 26. These 26 were digested in nitro-muriatic acid. The residuum now weighed 13 (so that 13 had been dissolved), 12 of which were sulphur, and burnt away, leaving behind them one part of silex. The nitro-muriatic solution, when diluted largely with water, let fall a precipitate which weighed 13 (or 10 of pure antimony), and had the properties of oxid of antimony; for they did not evaporate till heated to redness, but at that temperature were dissipated in a grey smoke.

The nitric solution was green. Common salt occasioned a precipitate which weighed 87.75, equivalent to 65.81 of pure silver. After the separation of this muriate of silver, sulphate of soda occasioned no precipitate. Therefore the solution contained no lead. When supersaturated with soda, a grey precipitate fell weighing 5 parts. On burning coals this precipitate gave out an arsenical smell. It was re-dissolved in nitric acid; sulphuret of potash occasioned a smutty brown precipitate; and Prussic alkali

a Prussian blue, which, after torrefaction, was magnetic. Hence he concluded, that these 5 parts were a combination of iron and arsenic acid.*

Red silver ore was analyzed by Vauquelin in the following manner: One hundred parts of it were digested in 500 parts of nitric acid previously diluted with water.† The undissolved residuum, being washed and dried, weighed 42.06. Being treated with muriatic acid, it was all dissolved except 14.66 parts, which were sulphur. The muriatic solution, when diluted with a great quantity of water, deposited a white powder, which weighed 21.25, and was oxid of antimony. The nitric solution remained still to be examined. Muriatic acid occasioned a heavy precipitate, which was muriate of silver. Reagents showed that the acid retained no other substance in solution.‡

Muriate of silver was analyzed by Klaproth in the following manner: One hundred parts of it were mixed with thrice their weight of pure carbonate of potash, and melted together in a glass retort. The mass was dissolved in water, and the solution filtered. A residuum remained, which was dissolved in nitric acid, with the exception of a red powder; which, treated with nitro-muriatic acid, was dissolved, except a little muriate of silver, which, when reduced, yielded .5 of pure silver. Ammonia precipitated from the nitro-muriatic solution 2.5 parts of oxid of iron. The nitric solution was precipitated by common salt; the muriate of silver, thus obtained, yielded, when reduced, 67.25 of pure silver.

The original aqueous solution of the alkaline mass was saturated with acetous acid, on which it deposited 1.75 parts of alumine. The solution was evaporated to dryness, and the dry mass treated with alcohol, which dissolved the acetite of potash. The

* Klaproth's Beiträge i. 163

† No effervescence occurred during the solution; a proof that the metals existed in the ore in the state of oxids.

‡ Journ. de Min. No. xvii. p. 2.

residuum, amounting to 58.75 parts, was dissolved in water; and being treated with muriate of barytes, 15 parts of sulphate of barytes precipitated, indicating the presence of about .5 of sulphuric acid, or 0.75 sulphate of potash. The remaining 58 parts were muriate of potash, indicating about 21 parts of muriatic acid.*

METHOD OF SEPARATING SILVER FROM COPPER.

It is a valuable discovery of Mr. Keir, that a mixture of strong sulphuric acid with the nitrous acid, or nitrate of potash, is a powerful solvent of silver, though it scarcely acts upon the other metals. This is of considerable importance in the Birmingham manufactures, where the silver in the cuttings of plated copper is required to be separated from this last metal. For this purpose the pieces of metal are put into a glazed earthen pan, and a composition of eight or ten pounds of sulphuric acid, with one pound of nitrate of potash, is poured upon them, stirred, and the action of the fluid assisted by a heat between 100° and 200° Fahr. When the liquor is nearly saturated, the silver is to be precipitated by common salt, which may be easily afterwards reduced; or, otherwise, the silver may be precipitated in its metallic state by adding to the solution a few of the pieces of copper, and a sufficient quantity of water, which enables the liquor to act on the copper. The theory of this effect still remains to be investigated.

The method of obtaining pure silver has been noticed already, p. 149.

The standard silver of Great Britain contains 15 parts of silver and one of copper.

In the solder used to join different parts of silver utensils, this proportion of copper is considerably greater, hence it is that such vessels are apt to oxidate, or become covered with a green oxid at the places where they are soldered.

* Klaproth's Beiträge, i. 132.

GOLD.

PART LIV.

SECT. I.

NATURAL HISTORY OF GOLD.

GOLD is found in nature only in a metallic state ; most commonly in grains, ramifications, leaves, or rhomboidal, octahedral, or pyramidical crystals. Its matrix is generally quartz, sandstone, siliceous shistus, &c. It is found also in the sands of many rivers, particularly in Africa, Hungary, and France, in minute irregular grains, called *gold-dust*. Native gold, found in compact masses, is never completely pure ; it is alloyed with silver or copper, and sometimes with iron and tellurium. The largest piece of native gold that has been hitherto discovered in Europe was found in the county of Wicklow, in Ireland. Its weight was said to be 22 ounces, and the quantity of alloy it contained was very small. Several other pieces, exceeding one ounce, have

also been discovered at the same place, in sand, covered with turf, and adjacent to a rivulet.

Gold is also met with in a particular sort of argentiferous copper pyrites, called in Hungary *Gelf*. This ore is found either massive, or crystallized in rhomboids, or other irregular quadrangular or polygonal masses. It exists likewise in the sulphurated ores of Nagaya in Transylvania. These all contain the metal called tellurium. Berthollet and other French chemists have obtained gold out of the ashes of vegetables.

PROPERTIES OF GOLD.

Gold is of a brilliant rich yellow colour; no other substance in nature is so heavy, platina excepted. Its specific gravity is 19.3. Its hardness is not very considerable. Its ductility is so considerable that a wire $\frac{1}{10}$ of an inch in diameter supports a weight of 500lb. without breaking. It melts at 32° of Wedgwood's pyrometer, and when suffered to cool slowly crystallizes in short quadrangular pyramids. By an intense heat, as that of a mirror, it is volatilized. It is incapable of oxidating at any temperature which our furnaces can yield. It is a good conductor of caloric, electricity, and galvanism. The two last agents inflame it, and convert it into a purple oxid which is volatilized in the form of smoke. It does not unite with hydrogen, carbon or with sulphur; though the latter when in the state of a sulphuret dissolves it. Phosphorus combines with it; arsenic, bismuth, and antimony form an intimate union with it. It easily alloys with mercury. With silver it forms an alloy of considerable ductility. Copper heightens its colour and renders it harder without much impairing its ductility. Tin and lead greatly impair its tenacity. With platina it forms an alloy which is considerably ductile. Combined with zinc it affords a very brittle and hard mixture susceptible of a beautiful polish. It unites well with iron and hardens it remarkably. Its ductility and malleability are far greater than any of the rest of the metals.

REMARK...One grain of gold may easily be divided into two millions of parts; and a cubic inch of gold, into nine thousand five hundred and twenty-three millions, eight hundred and nine thousand five hundred and twenty-three parts, each of which may be distinctly seen by the naked eye.

Boyle, quoted by Apligny in his Treatise of Colours, says, that one grain and a half of gold may be beaten into 50 leaves of one inch square, which if intersected by parallel lines drawn at right angles to each other, and distant only the 100th part of an inch from each other, will produce 25 millions of little squares, each of which may be distinctly seen without the help of glasses.

Mr. Magellan has informed us that its surface may be extended by the hammer 159,092 times, and that the finest gold-leaf is that made in new skins, which must have an alloy of three grains of copper to the ounce troy of pure gold, or it would be too soft to pass over the irregularities of the skin.

He affirms, that 80 books, or 2000 leaves of gold, each measuring 3.3 square inches, viz. each leaf containing 10.89 square inches, weigh less than 384 grains. Each book therefore, or 25 leaves = 272.23 inches, weigh less than 4.8 grains; so that each grain of the metal will produce 56.718 square inches. From further calculations it may be made evident, that the thickness of these leaves, is less than $\frac{1}{282620}$ th of an inch; and that sixteen ounces of gold, which if in the form of a cube, would not measure more than one inch and one quarter on its side, will completely gild a silver wire sufficient in length to go round the whole earth like a hoop.

METHOD OF OBTAINING GOLD.

The processes for obtaining gold, in the large way, from its different native combinations, or admixtures, vary, according to the state of the gold, and the nature of the substances which are found mixed with it.

When gold is in a state nearly pure, (*native gold*) as it is found dispersed among stones, or mixed with sand, it may first be reduced to small granular pieces, together with the matrix; a table of several feet long, and one and a half broad, with ledges round three of its sides, and pieces of cloth with a long nap nailed on the board, is placed under a gentle stream of water, upon which the pounded ore or sand is thrown; by this contrivance, the lighter and heterogeneous substances are washed or carried off.

When the stuff or cloth is sufficiently charged with the particles of gold which adhere to it, on account of its superior gravity, it is disengaged from the board, and put into a vessel, where it is further agitated with water, and more freed from the lighter substances. It is then mixed with $\frac{1}{10}$ of mercury, and triturated in an iron or copper vessel containing boiling water, until the mercury has absorbed all the gold particles. The mercury thus containing the gold in solution, is to be separated, first from the water, next from the earthy particles, and then from the sand, by throwing the whole upon a table placed in an inclined direction; the mercury charged with gold, but still vivid, will when assisted by a little stirring, or manipulation, run off the table, and leave the sand behind. The mercury is then separated from the gold, (and silver if any) by exposing the alloy in earthen retorts to such a heat as will occasion the mercury to distill off, and is collected again in a receiver with water. The gold not being volatile in fire, is thus left behind, and is afterwards further freed from the heterogeneous imperfect metallic substances, by the process of cupellation.

After these processes, the silver, if the gold contains any, is separated by reducing it first to very fine laminæ, and then extracting the silver by nitric acid, which leaves the gold behind; the silver may be separated from the nitric acid, by muriatic acid, with which it forms muriate of silver. Muriate of silver is to be decomposed again, by mixing it with soda, and expos-

ing it to a sufficient heat in a crucible, whereby the soda unites to the muriatic acid, and sets the silver free.

When gold is found mixed with sulphur or arsenic, and other metals, the ore must first be torrefied, which separates the greatest part of the arsenic and sulphur, and then melted with iron, which unites with what remains. The heterogeneous metallic substances are then separated by scorification with fluxes, consisting of tartrate of potash and nitrate of potash, which have no effect upon gold when the sulphur is previously separated; without this previous separation, the sulphur would unite with part of the alkali of the nitrate of potash, and form sulphuret of potash, which would take up a portion of the gold, and thus diminish the produce. The gold left by the melting with the flux, is afterwards further purified by cupellation, or melting with lead.

When the gold ore is free from sulphur, it may after being pounded and washed, be melted with one and a half part of semi-vitreous oxid of lead, and three parts of glass, in a crucible covered with muriate of soda. By this operation, all the heterogeneous metals will scorify, and set the gold free.

SECT. II.

EXPERIMENTAL PROOFS
OF
THE PROPERTIES OF GOLD.

EXPERIMENT I.

Gold is not acted on by any acid, the oxygenated muriatic and nitro-muriatic acid excepted.

INTRODUCE some gold-leaf into any acid, no solution will be effected by it; but if oxygenated muriatic acid, or nitro-muriatic acid, be made use of, a solution will be effected. If the gold-leaf be exposed to the action of the oxygenated muriatic acid in its gaseous state, it takes fire. (See vol. i. p. 33.)

A saturated solution of gold in these acids yields, by evaporation, crystals of muriate of gold, of a beautiful yellow colour, not unlike *topazes*; they consist sometimes of truncated octahedra, sometimes of tetrahedral prisms. When dissolved in water they tinge the skin indelibly of a deep purple colour, and produce the same effect upon almost all animal and vegetable bodies, and even upon marble.

RATIONALE...The gold robs the acid of part of its oxygen, and becomes oxidated; the oxygenated muriatic acid, or the nitro-muriatic acid, is converted into simple muriatic acid, in which state it is capable of dissolving the oxid of gold, and constitutes with it *muriate of gold*.

REMARK....Though nitro-muriatic, or more properly oxygenated muriatic acid, is the only fluid capable of dissolving gold, it has been long ago noticed that nitrous acid, assisted by heat, exercised some slight action on this metal, especially when in a state of extreme comminution.

EXPERIMENT II.

Gold is precipitated from its solution by tin.

(Preparation of the purple precipitate of Cassius.)

If we immerse into a solution of gold in nitro-muriatic acid a sheet of tin, the oxid of gold is precipitated of a purple colour, and, when scraped off and collected, forms the purple powder, or precipitate of Cassius, much employed in enamelling. It is a compound, consisting of oxid of gold and oxid of tin. It is best obtained, for the purpose of enamelling, by dissolving pure tin in diluted nitro-muriatic acid, composed of two parts of nitric and one of muriatic acid, very slowly, and absolutely without heat, and then adding to this fresh-prepared solution, diluted with at least eighty times its weight of distilled water, a solution of pure gold in nitro-muriatic acid, collecting the precipitate, and washing it repeatedly with distilled water.

REMARK...It is absolutely necessary that the tin should be oxidated at its *minimum*, for the oxi-muriate of tin, which is already at a *maximum* of oxidation produces no such effect, because it cannot abstract oxygen from the oxid of gold.

EXPERIMENT III.

Gold is precipitated from its solution by charcoal.

Into a perfectly neutral diluted solution of gold, contained in a glass jar, put a long narrow slip of well-burnt charcoal, and

expose it to the direct rays of the sun ; the gold will be revived and appear on the charcoal in a metallic state, exhibiting a very beautiful appearance. The same effect will be produced, without light, by boiling the charcoal in the solution for a few minutes.

EXPERIMENT IV.

Gold is also precipitated by ether, essential oils, &c.

If highly-rectified ether, or a pure essential oil, be shaken together with a solution of gold, the gold will be precipitated, but it will be instantly dissolved by the ether or oil, and form with the first an *etherial solution of gold*, which is of a golden-yellow colour, and floats on the top of the fluid.

If the solution be evaporated the gold is obtained in a state of absolute purity.

REMARK...Gold thus dissolved was formerly called *potable gold*. It was anciently employed in medicine. The apothecaries made their patients supply the gold, and pretended that the purer the gold, so much the speedier would be the cure. But these errors have been long exploded.

EXPERIMENT V.

Decomposition of nitro-muriate of gold by hydrogen or sulphureous acid gas.

For these facts we are indebted to Mrs. Fulhame. She found, that if a white satten ribbon be moistened with a diluted solution of gold in nitro-muriatic acid, and then exposed, while moist, to a current of hydrogen gas, the gold would be reduced, and the ribbon become gilt with the metal. But if the silk be dried previously, the reduction does not take place. By

means of a camel-hair pencil, the gold may be so applied as to exhibit regular ornaments, or figures, when reduced.

The same reduction takes place when the silk is dipped into phosphorated ether. If a piece of silk, moistened with phosphorated ether, be immersed in the nitro-muriatic solution, its surface is immediately gilt with a fine coat of gold, which adheres very strongly.

That phosphorated hydrogen gas produces the same effect has been noticed already, (vol. i. p. 276). Sulphureous acid gas has a similar effect.

REMARK...Mrs. Fulhame has proved* that the presence of moisture is absolutely necessary for the reduction of gold. It is difficult to ascertain what makes water so indispensably necessary. It is not, as might be supposed, requisite to secure the fluidity of the mixture; for she has ascertained that sulphuric ether, though a fluid, does not answer, except water be present. She accounts very ingeniously for the phenomena, by supposing the water to be decomposed. The combustible combines with its oxygen, while its hydrogen unites to the oxygen of the gold, and re-produces water. This theory accounts very well for the phenomena; but it would require some direct proofs to establish it completely.

EXPERIMENT VI.

Decomposition of nitro-muriate of gold by ammonia.

(Preparation of fulminating gold.)

Dissolve pure gold in nitro-muriatic acid to saturation, and dilute the solution with three times its bulk of distilled water, and add to it gradually some pure ammonia, a yellow precipitate

L 4

* In her Essay on Combustion.

will be obtained, which must be repeatedly washed with distilled water, and dried on a chalk stone or in a filter. When perfectly dry it is called *fulminating gold*, and detonates by heat as may be shown by heating a few grains of it on the point of a knife held over the candle.

RATIONALE...Though the theory of fulminating gold is not yet sufficiently illustrated, it appears highly probable that it is a triple compound; namely, an *ammoniocal oximuriate of gold*. We suppose therefore, that on the application of heat, the muriatic acid seizes the oxygen, and reduces the gold to its metallic state; while the acid itself becomes converted into oxygenated muriatic acid. We suppose farther, that after this change the acid detonates with the ammonia; in which case, part of its oxygen forms water with the hydrogen of the ammonia, and its nitrogen is set free. Hence the products of the detonation of fulminating gold seem to be metallic gold, nitrogen gas and muriatic acid and water.

EXPERIMENT VII.

Gold is precipitated from its solution by sulphate of iron.

If we mingle a solution of gold with a diluted solution of green sulphate of iron, a precipitate instantly appears, which is gold in its metallic form, and in a state of absolute purity.

RATIONALE...The green sulphated oxid of iron seizes the oxygen of the gold, and hence the former re-appears in its metallic state.

REMARK...The red sulphate of iron has no effect upon the solution of gold; the reason of this may be readily conceived from what has been stated before.

EXPERIMENT VIII.

*A solution of gold stains animal and vegetable matters
purplish red.*

If a solution of gold be applied to bone, ivory, wood, feathers, linen, silk, &c. a stain will be left of a purplish-red colour, which cannot be effaced, on account of the strong attraction subsisting between the oxid of gold and the substance to which it is applied. The traces are first purple, they afterwards become of a beautiful brown, and at last black. Hence a diluted solution of gold may be used for painting upon silk.

EXPERIMENT IX.

*Gold may be separated from its combinations with other metals
by sulphuret of antimony.*

Put the alloy into a crucible with two parts of sulphuret of antimony, and when the mixture is in perfect fusion, take the crucible out of the fire and suffer it to cool; a sulphuret will be formed with the foreign metals at the upper part, and the gold will be found united to the antimony at the bottom of the crucible.

The gold may be separated from the antimony by bringing it to a white heat, by which means the antimony is volatilized.

EXPERIMENT X.

Gold when united to mercury is easily oxidated.

Put mercury with a forty-eighth part of its weight of gold into a flat-bottomed matrass, the neck of which must be drawn out into a capillary tube, and expose the mixture to heat in a sand-bath; the metals will become oxidated and be converted into a dark-coloured powder.

EXPERIMENT XI.

Gold unites with alkaline sulphurets both in the dry and humid way.

To exhibit this, some leaf-gold may be digested with heat in a solution of sulphuret of potash. Or,

Equal parts of sulphur and potash may be fused quickly with gold-leaf.

REMARK...Some chemists have persuaded themselves that this was the process made use of by Moses to render the Golden Calf, which the Israelites cast in that metal and set up in the wilderness, to worship during Moses's absence on the Mount, potable, which, as related in Exod. XXXII. that legislator ground to powder, burnt, and mixt with the water the people were to drink. There is however nothing related concerning the operations necessary for that purpose.

GILDING,

Or the art of covering the surfaces of bodies with gold. Manufacturers use the term improperly to denote silvering, as well as gilding, and likewise the various methods of producing a golden colour without actually using gold.

The real application of gold, as a covering, may be performed, either by a metallic mixture after the manner of a pigment; or by friction, upon the same principle as black-lead, and coloured chalks are used; or by the chemical precipitation of gold from mercury, or some other fit solvent; or, lastly, by glueing, or fastening extremely thin leaves of gold, to the surface intended to be gilt.

Shell-gold, or gold-powder

For painting, may be obtained by uniting one part of gold with eight of mercury, and afterwards evaporating the latter by heat, which leaves the gold in the form of powder; or otherwise the metal may be reduced to powder by mechanical trituration, as mentioned already under the article *shell-silver*.

Cold gilding by friction.

Steep a fine linen rag in a saturated solution of gold, till it has entirely imbibed the fluid; this rag must then be dried over a fire, and afterwards burnt to tinder. When any thing is to be gilt, it must be previously well burnished; a piece of cork is then to be dipped, first into a solution of salt in water, and afterwards into the black powder; and the piece, after being rubbed with it, must be burnished. This powder is frequently used for gilding delicate articles of silver.

Gilding of brass or copper.

Fine instruments of brass, in order that their surface may be kept longer clean, may be gilt by immersing them several times in a solution of muriate of gold, free from excess of acid, and afterwards burnishing them.

Water-gilding.

This term was probably at first confined to such processes as demand the use of a solution of gold in nitro-muriatic acid, and means a chemical application of gold to the surfaces of metals. If a solution of gold be copiously diluted with ardent spirit, a piece of clean iron will be gilt by being repeatedly steeped therein.

An improved process for gilding iron or steel.

This method which is less known among artists than it deserves to be, may prove useful to those who have occasion to gild iron or steel.

The first part of the process consists in pouring into a solution of gold in nitro-muriatic acid, about twice as much sulphuric ether. In order to gild iron or steel, the metal must be well polished with the finest emery, or rather with the finest red oxid of iron and spirit of wine. The ether which has taken up the gold is then to be applied with a small brush; it evaporates, and the gold remains on the surface of the metal; the metal may then be put into the fire, and afterwards polished. In this manner all kind of figures may be delineated on iron, by employing a pen or fine brush.

Gilding of iron, by means of heat,

Is performed by cleaning and polishing its surface, and then heating it, till it has acquired a blue colour. When this has been done, the first layer of gold-leaf is put on, slightly burnished down, and exposed to a gentle fire. It is usual to give three such layers, or four at the most, each consisting of a single leaf, for common works; or two for extraordinary ones. The heating is repeated at each layer, and last of all the work is burnished.

Grecian gilding

Is performed in the following manner: Equal parts of muriate of ammonia, and muriate of mercury, are dissolved in nitric acid, and a solution of gold is made in this menstruum; upon this the solution is somewhat concentrated, and applied to the surface of silver, which becomes quite black; but on being exposed to a red heat, it assumes the appearance of gilding.

Method of gilding silver, brass, or copper, by means of an alloy of gold and mercury.

Eight parts of mercury and one of gold, are alloyed together by heating them in a crucible. As soon as the gold is perfectly alloyed, the mixture is poured into cold water, and is then ready for use.

Before the alloy can be laid upon the surface of the metal, this last is brushed over with diluted nitric acid, in which it is of advantage that some mercury may have been dissolved. Some artists then wash the metal in simple water, and scour it a little with the finest sand, previous to the application of the gold; but others apply it to the metal while still wet with the nitric acid. But in either case, the alloy must be laid on as uniformly as possible, and spread very even with a brass wire-brush, wetted from time to time with water. The piece is then laid upon a grate, over a charcoal fire, or in a small oven, or furnace, adapted to this purpose; the heat drives off the mercury, and leaves the gold behind. Its defects are then seen, and may be remedied by successive applications of more amalgam, and additional application of heat. Expert artists however make these additional applications while the piece remains in the furnace, though the practice is said to be highly noxious, on account of the mercurial fumes. After this it is rubbed with gilders wax, which may consist of four ounces of bees wax, one ounce of acetite of copper, and one ounce of sulphate of copper; they then expose it to a red heat, which burns off the wax; and lastly, the work is cleansed with the scratch brush, and burnished, if necessary, with a steel tool. The use of the wax seems to consist merely in covering defects, by the diffusion of a quantity of red oxid of copper, which is left behind after the burning.

Painting with gold upon porcelain, or glass

Is done with the powder of gold which remains behind after driving off the nitro-muriatic acid from a solution of that metal,

or by precipitating this solution by immersing plates of copper in it. It is laid on with super-saturated borate of soda and gum-water, or oil, burned in and polished.

The gilding of glass

Is commonly effected by covering the part with a solution of super-saturated borate of soda, and applying gold-leaf upon it, which is afterwards fixed by burning.

The edges of tea cups, &c.

Are frequently gilt in a less durable manner by applying a very thin coat of amber varnish, upon which gold-leaf is to be fixed, and when the varnish is dry, the gold is burnished.

The gilders of wood, and other compositions designed to supply the place of carved work, make use of gold leaf, which is either laid on with size, or boiled oil, and afterwards burnished.

ANALYSIS OF ORES OF GOLD.

Native gold when imbedded in earths, or stones, may be analyzed by reducing the ore to a very fine powder, weighing a determinate portion, and effecting their solution in nitric or rather in nitro-muriatic acid, care being taken to digest the ore with the acid repeatedly, or as long as it extracts any thing. The solution must be evaporated to dryness, in order to force it as much as possible from its excess of acid, and then dissolved in water. If the ore contains silver this metal will fall to the bottom in the form of a white heavy precipitate; it may be separated by filtration and reduced by fusing it with soda. In order to separate the gold, let the solution be made hot and pour into it a solution of sulphate of iron, which will precipitate the

gold in its metallic state. The presence of copper in the ore may be detected by immersing a plate of iron in the solution, which will become coppered. Iron may be detected by tincture of galls, which occasions a blackish precipitate; and platina, by muriate of ammonia, which separates it. The minutest quantity of gold contained in an ore may be investigated, by letting fall into the solution a few drops of a solution of tin in muriatic acid, and which will instantly cause a purple precipitate.

When gold is found in sands it can be obtained by simply washing the sand, for the lighter foreign substances will remain longer suspended, and carried off with the water, while the heavy particles of gold sink to the bottom with greater celerity.

PARTING, OR QUARTATION.

If gold be alloyed with silver, it is purified by a process sometimes called *parting*, and sometimes *quartation*: this last name is given on account of the proportion of materials employed; three parts of silver being added to the alloy, which of course makes a fourth part of the mixture. They are melted together, and sulphur thrown in: the sulphur combines with the silver, and the gold falls to the bottom. In the humid way gold is purified from silver by the nitric acid, which rapidly dissolves silver, but has no action upon gold.

CUPELLATION.

If gold be alloyed with copper, lead, &c. it is purified by the process called *cupellation*, in the following manner: the alloyed gold is put with about twice its weight of silver, and some lead, into a crucible made of a very porous substance, such as bone-ashes, and called a *cupel*. They are all exposed to a considerable heat, which oxidates the lead, or converts it into a semi-vitreous

oxid of lead or litharge, enabling it likewise to form a similar kind of substance with the other metals in the alloy. This glassy fluid soaks into the pores of the cupel, while the remaining mixture of gold and silver is left behind in the vessel: the silver is then separated from the gold as before, by parting.

It must be observed, that every alloy of gold is supposed to be divided into twenty-four parts, called *carats*, and that the purity of gold is estimated according to the number of those parts, which it makes up.

The gold coins of Great Britain are composed of 11 parts of gold, and 1 of copper; they are therefore gold of twenty-two carats.

Perfectly pure gold may be obtained by dissolving the gold of commerce in nitro-muriatic acid, and precipitating the metal by adding a weak solution of sulphate of iron. The precipitate after being well washed and dried, is pure gold.

PLATINA.

PART LV.

SECT. I.

NATURAL HISTORY OF PLATINA.

HITHERTO no mine of platina has been discovered. It is found in nature, only in a metallic state in small grains, combined with iron, copper, plumbago, &c. The largest mass of which we have heard, is one of the size of a pigeon's egg, in the possession of the Royal Society of Bergara. It is found in the parishes of Novita and Citaria, North from Choco in Peru, and near Carthagena in South America. It was unknown in Europe before the year 1748. Don Antonio Ulloa then gave the first information concerning its existence in the narrative of his voyage with the French Academicians to Peru.

PROPERTIES OF PLATINA.

Platina purified from all extraneous mixture is of a white colour, intermediate between that of silver and tin. It is the hardest of all metals. Its specific gravity being from 20.6 to 23, makes it by far the heaviest body known. It is hard, malleable, ductile, laminable like gold; but to what degree is not yet ascertained. We have seen platina drawn into a wire of a smaller diameter than the two thousandth part of inch. It is the most infusible of all the metals. It cannot be melted (in a considerable quantity at least) by the most violent heat of our furnaces, but may be fused by the heat of a burning lens, or by the assistance of oxygen gas. When pure, its parts may be made to combine or weld, by hammering in a white heat; a property confined to this metal and iron. It suffers no alteration from the action of air; neither water, the earths, nor the salino-terrene substances have any power of re-action upon it. Potash acts upon it at high temperature. It is not oxidated when exposed red-hot to the air, for a very long time. It may however be oxidated by the galvano-electric spark, and by the nitro-muriatic acid. This acid dissolves it and assumes first a yellow and afterwards a deep orange colour. The solution tinges animal substances with a dark colour, and may be decomposed by alcalies and by muriate and nitrate of ammonia, which have no effect on solutions of gold. No other acid exercises any action upon it. The oxid of platina which is a triple compound, consisting of ammonia, muriatic acid, and platina may be reduced by the action of a violent heat. Platina combines with phosphorus and sulphur with considerable facility. It unites with the greater number of the metals by fusion. Of these alloys, that with copper is the most valuable, as it is ductile, susceptible of a fine polish, and does not tarnish on exposure to air; the rest of them are very little known, it is therefore unnecessary to dwell on them particularly.

METHOD OF OBTAINING PLATINA.

The processes most commonly employed to obtain pure platina, are as follows:

1. Take equal parts of platina in grains, and acidulous tartrite of potash, put the mixture into a well luted crucible, and expose it for two hours to a violent heat. The platina fuses, but it becomes brittle and whiter than platina is in common; then expose it to a very strong heat under a muffle, by which means all the arsenic combined with it will be disengaged, and the platina remain behind in a malleable state.

2. Platina may likewise be obtained pure, by decomposing the nitro-muriatic solution of common platina, by muriate of ammonia, heating the precipitate intensely, and stamping it when of a white heat into one mass: or, by assisting the fusion with a stream of oxygen gas.

3. Jannetty's process, which is considered as the best, and which is generally used for obtaining malleable platina, is as follows:

Triturate common platina with water, to wash off every contaminating matter that water can carry away. Mix the platina with about one-fifth part of arsenious acid and one fifteenth part of potash; putting the whole in a proper crucible, in the following manner: Having well heated the crucible and the furnace receiving it, put in one-third of the mixture, apply to this a strong heat, and add one-third more: after a renewed application of heat, throw in the last portion. After a thorough fusion of the whole, cool and break the mass. Then fuse it a second time, and, if necessary, even a third time, till it ceases to be magnetic. Break it into small pieces, and melt those pieces in separate crucibles, and in portions of a pound and a half of the platina to each crucible, with an equal quantity of arsenious acid and half a pound of potash. After

cooling the contents of the different crucibles in a horizontal position, in order to have them throughout of equal thickness, heat them under a muffle to volatilize the arsenious acid, and maintain them in this state, without increase of heat, for the space of six hours. Heat them, next, in common oil, till the oil shall have evaporated to dryness. Then immerse them in nitric acid, boil them in water, heat them to redness in a crucible, and hammer them into a dense mass. They are now fit to be heated in a naked fire, and hammered into bars for the purposes of commerce.

Mr. Richter directs, in order to purify platina, and render it malleable, the following process : Dissolve platina of commerce in nitro-muriatic acid, and let fall into this solution potash, until a precipitate begins to appear ; then add a solution of sulphate of potash, till the whole is precipitated. Wash the precipitate till the water that passes do not change its colour by adding to it prussiate of potash. Dry the precipitate, and mix with it 1.5 times its weight of soda, freed from its water of crystallization ; press it into a crucible, but not so as to fill it, heat it gradually, and raise the heat till it fuses.

SECT. II.

EXPERIMENTAL PROOFS

OF

THE PROPERTIES OF PLATINA.

EXPERIMENT I.

Platina is soluble in nitro-muriatic acid.

IF one part of platina and ten of nitro-muriatic acid be presented to each other a violent action takes place, and the platina becomes dissolved. On evaporating the solution, very small crystals of muriate of platina are deposited.

REMARK... This is the only saline combination of this metal, of which the properties have been examined; it appears that the platina exists in the solution in two states of oxidation. On adding potash to it, a precipitate is formed which is a triple compound of the alcali, acid, and platina highly oxidated; it is sparingly soluble in water and of a saline nature. When more potash is added, another precipitate is thrown down, which is the imperfect oxid of platina.

Ammonia acts in a similar manner on the solution; and the muriate of ammonia likewise forms a triple compound of oxid of platina, muriatic acid, and ammonia, which being insoluble is precipitated. *By this property of affording a precipitate on the addition of muriate of ammonia to its solution, platina is distinguished from every other metal.*

EXPERIMENT II.

Separation of platina from gold.

When gold is alloyed with platina, the adulteration cannot be discovered by hydrostatic examinations; but as muriate of ammonia has the property of precipitating platina, but not gold from the solution; and as fresh prepared sulphate of iron precipitates gold (see page 168) but not platina, these salts furnish the means of separating the metals when added to the solution.

EXPERIMENT III.

*Platina combines with phosphorus.**(Phosphuret of platina.)*

Mix equal parts of platina and glacial acid of phosphorus with an eighth part of charcoal, put the whole into a crucible, and cover it with a little charcoal dust; expose it to a heat nearly equal to that which makes gold enter into fusion, and continue it for an hour; a button of a silver-white colour will then be obtained, which exhibits in the inside, crystals of a perfect cubical form; this is *phosphuret of platina*.

EXPERIMENT IV.

Phosphuret of platina detonates with oxygenated muriate of potash.

If a mixture of phosphuret of platina and oxygenated muriate of potash be thrown into an ignited crucible, a strong detonation ensues, and the platina becomes separated in its metallic form.

A similiar effect is produced by throwing phosphuret of platina upon nitrate of potash in a state of fusion.

EXPERIMENT V.

Platina is soluble in potash in the dry way.

If potash, prepared according to Berthollet's process, be kept in fusion for some time in a platina crucible it will be found, that this vessel has lost part of its weight, which is dissolved by the potash. For if we dissolve this alcali in water, and saturate the solution with muriatic acid, a triple salt will be obtained by evaporation, consisting of platina, muriatic acid, and potash. This fact was first noticed by Mr. Chenevix.*

TANTALITE.

PART LVI.

NATURAL HISTORY OF TANTALITE.

SINCE the printing of the preceding sheets, a new metallic substance has been announced by Mr. Ekeberg, to which he has given the name of *Tantalite*. This metal exists in the mineral called Gadolinite, and also in a species of tin ore, or oxid of tin, (zin-graupen.) In the first of these minerals, tantalite exists combined with oxid of iron and manganese; in the latter it is united to *yttria*; hence the discoverer of this metal has called the latter mineral *ytthro-tantalite*. Both are found in considerable abundance in Sweden and Finland.

PROPERTIES OF TANTALITE.

Tantalite is distinguished from all other metals by being insoluble in any of the acids. It is acted on only by alcalies. The solution is decomposeable by a copious addition of acids in excess. The product obtained is of a white colour, which it retains after having been ignited. Its specific gravity is 6.500. It fuses with phosphate of soda and ammonia, or sub-borate of soda

into a colourless glass. Exposed to a high temperature with charcoal, it agglutinates and acquires a metallic aspect. Its fracture is brilliant, and its colour greyish black.

These properties together with its great specific weight have induced Mr. Ekeberg to consider it as a new metal.

The substances with which it might be confounded are the oxids of tin, tungsten, and titanium, all of which are more or less soluble in alcalies, and under certain circumstances resist the action of acids. But it is well known that the oxid of tin is easily reducible, whereas the oxid of tantalite requires an intense heat to reduce it even imperfectly. The oxid of tungsten is soluble in ammonia, but that of tantalite is not. The colour communicated to phosphate of soda and ammonia by fusion with the oxid of titanium is yellow or hyacinth colour, and that of the oxid of tungsten is blue; but oxid of tantalite fuses with these salts into a colourless glass.

Whether this substance will retain its place among the metals, must be left to future investigation, at present we have only the authority of Mr. Ekeberg* for inserting it.

* Journal de Mines, No. 20, An. x, p. 248, and Annales de Chimie, An. x, p. 276.

EARTHS.

EARTHS.

PART LVII.

THOUGH there seems to be an almost infinite variety of earthy substances scattered on the surface of this globe; yet when we examine them with a chemical eye, we find, not without surprize, that all the earth and stones which we tread under our feet, and which compose the largest rocks, as well as the numerous different specimens which adorn the cabinets of the curious, are composed of a very few simple or elementary earths, in number no more than seven.

ENUMERATION OF EARTHS.

SILEX,	ZIRCON,
ALUMINE,	AGUSTINE,
GLUCINE,	YTTRIA,
MAGNESIA.	

These are all the simple earths hitherto known: none of them have yet been decomposed, nor has the smallest proof been

brought that they are compound; we must therefore consider them as simple bodies, which nature presents to us completely formed, though one or more of them enters into the composition of a great many bodies. They have a variety of properties which are common to all.

GENERAL PHYSICAL PROPERTIES OF EARTHS.

All earths are dry incombustible bodies. They are insoluble in water, and alcohol, or nearly so. They have little or no taste. Their specific gravity does not exceed 4.9. When perfectly pure they assume the form of a white powder, harsh to the touch. They are infusible. They are capable of combining with acids, when they form neutral salts. They are likewise disposed to unite with the alcalies, with sulphur, and phosphorus; with metallic oxids, and with each other, either by fusion or solution in water.

Every one of these characters is not perhaps rigorously applicable to each of these bodies; but they all possess a sufficient number of them to render it useful to arrange them under one class.

Stones differ from earths principally in cohesion and hardness, and therefore are included under the same general name.

SILEX.

PART LVIII.

SECT. I.

NATURAL HISTORY OF SILEX.

SILEX, or siliceous earth, is the principal constituent part of a very great number of the compound earths and stones forming the immense mass of the solid nucleus of the globe. It is the basis of almost all the scintillating stones, such as *flint*, *rock crystal*, *quartz*, *agate*, *calcedony*, *jasper*, &c. The sand of rivers and of the sea-shore, chiefly consist of it. It is deposited in vegetable substances forming petrified wood, &c. It is likewise precipitated from certain springs in a stalactitical form. It has been discovered in several waters in a state of solution, and is found in many plants, particularly grasses and equisetums. Professor Davy has proved that it forms a part of the epidermis of these vegetables. It is never met with absolutely pure in nature.

PROPERTIES OF SILEX.

Silex when perfectly pure exists in the form of a white powder. It is insipid and inodorous. It is rough to the touch, cuts glass, and scratches or wears away metals. Its specific gravity is about 2.66. It is unalterable by the simple combustible bodies. When mixed with water it does not form a cohesive mass. Its molecularae when diffused in water are precipitated with the utmost facility. It is not acted on by any acid, except the fluoric. When in a state of extreme division it is soluble in alcalies; fused with them it forms glass. It melts with the phosphoric and boracic acids. It is unchangeable in the air and unalterable by oxygen and the rest of the gaseous fluids. It has been considered as insoluble in water, but it appears when in a state of extreme division to be soluble in a minute quantity.

METHOD OF OBTAINING SILEX.

Silex may be obtained, tolerably pure, from flints, by the following process: Procure some common gun-flints; expose them in a crucible to a red heat, and then plunge them into cold water; by this treatment they will become brittle, and easily reducible to powder. Mix them, when pulverized, with three or four times their weight of carbonate of potash, and let the mixture be fused, in a dull red heat, in a silver crucible. We shall thus obtain a compound of alcali and silex, called siliceous potash. Dissolve this compound in water, filter the solution, and add to it diluted sulphuric or muriatic acid. An immediate precipitation now ensues, and as long as this continues, add fresh portions of acid. Let the precipitate subside; pour off the fluid that floats above it; and wash the precipitate with hot water till it comes off tasteless. This powder when dry is silex.

RATIONALE...The acid added to the solution of flint unites to the potash, and forms sulphate or muriate of potash; the siliceous earth is therefore precipitated.

REMARK...It is necessary to add excess of acid, in order that all the foreign earths which are present may be separated.

If the solution of flints be diluted with a great quantity of water, as for instance, in the proportion of 24 parts to one, and in this state an acid be poured upon it, no perceptible precipitation will ensue; the silex continues suspended in the fluid, and is invisible on account of its transparency; but it may be made to appear by evaporating part of the water.

The solution of flint, on account of its affinity with the carbonic acid is also in course of time decomposed by mere contact with air.

Another method of obtaining silex exceedingly pure is to separate it from fluoric acid. We shall notice this process in treating of that acid.

SECT. II.

EXPERIMENTAL PROOFS

OF

THE PROPERTIES OF SILEX.

EXPERIMENT I.

Silex when mixt with water does not form a cohesive compound, but separates instantly.

LET any quantity of silex and water be mingled together in a phial, the silex will instantly separate, and the water remain transparent as before.

EXPERIMENT II.

Silex is not acted on by any acid except the fluoric.

Put a determinate quantity of silex in a Florence flask, and boil it in any quantity of sulphuric, nitric, muriatic, acetic, &c. acid; on decanting the acid and examining the earth when dry, it will be found to have sustained no loss of weight. A proof that the acid has dissolved nothing.

EXPERIMENT III.

Silex is soluble in fluoric acid.

Put one part of silex into twelve of fresh prepared fluoric acid, contained in a leaden or tin bottle, close the bottle with a stopper

made of wax; let it stand for a few days and agitate it frequently. On examining the contents the silex will be found to be dissolved in the acid.

EXPERIMENT IV.

Silex is dissolved by alcalies in the humid way, when in a state of extreme division.

This may be proved by boiling one part of pure silex, minutely divided, in a silver vessel with 20 parts by weight of a concentrated solution of potash or soda. The earth will be dissolved, and may be separated again by the addition of an acid.

EXPERIMENT V.

Silex is soluble in alcalies by fusion.

The method of obtaining silex, as mentioned before, furnishes a proof of this.

EXPERIMENT VI.

Silex is fusible with the phosphoric and boracic acids.

Place a few grains of silex and glacial acid of phosphorus or borax, on a bit of charcoal, and urge it by means of the blow-pipe; the mixture will melt and form a globule of transparent glass.

The other properties of this earth may be investigated without any description.

FORMATION OF GLASS.

Glass is obtained by mixing silex with a proper proportion of soda or potash, and exposing this mixture to a violent heat.

When these substances are completely fused and have acquired a certain degree of heat, which is known by the fluidity of the mass, part of the melted matter is taken out at the end of a long hollow tube, which is dipped into it, and turned about until a sufficient quantity is taken up; the workman at each turn rolling it gently upon a piece of iron, to unite it more intimately. He then blows through the tube, till the melted mass at the extremity swells like a bubble, after which he rolls it again on a smooth surface to polish it, and repeats the blowing, until the glass is brought as near the size and form of the vessel required, as he thinks necessary.

If it be a common bottle, the melted matter at the end of the tube is put into a mould of the exact size and shape of its body, and the neck is formed on the outside by drawing out the ductile glass.

If it be a vessel with a large or wide orifice, the glass in its melted state is opened and widened with an iron tool; after which being again heated, it is whirled about with a circular motion, and by means of the centrifugal force thus produced is extended to the size required. Should a handle, foot, or any thing else of the kind be required, these are made separately, and stuck on in its melted state.

Window-glass is made in a similar manner, except that the mass at the end of the tube is formed into a cylindrical shape, which being cut longitudinally by scissors or shears, is gradually bent back until it becomes a flat plate.

Large plate-glass for looking-glasses, &c. is made by suffering the mass in a state of complete fusion to flow upon a casting-table, with iron ledges to confine the melted matter, and as it cools, a metallic roller is passed over it to reduce it to an uniform thickness. There are different kinds of glass manufactured for different purposes; the principal of these are *flint-glass*, *crown-glass*, and *bottle-glass*.

Flint-glass is the densest, most transparent, colourless, and beautiful. It is often called *crystal*. The best kind is said to be

manufactured in this capital from 120 parts of white siliceous sand, 40 parts of pearl-ash, 35 of red oxid of lead, 13 of nitrate of potash, and 25 of black oxid of manganese.

This is the most fusible glass. It is used for bottles and other utensils intended to be cut and polished, and for various ornamental purposes.

Crown-glass differs from the preceding, in containing no lead. It is manufactured of soda and fine sand. This kind is used for panes of windows, &c.

Bottle-glass is the coarsest of all. It is made of soda and common sand. Its green colour is owing to iron. It is the least fusible.

Glass is often coloured by mixing with it while in a fluid state various metallic oxids. It is coloured *blue* by the oxid of cobalt; *red* by the oxid of gold; *green* by the oxid of copper or iron; *yellow* by the oxid of silver or antimony; and *violet* by the oxid of manganese.

The properties of glass are well known. Its hardness is very considerable; its gravity varies from 2.3 to 4, according to the quantity of metallic oxid which entered into its composition. Though glass when cold is brittle, it is one of the most ductile bodies known. If a thread of melted glass be drawn out and fastened to a reel, the whole of the glass can be spun off on the reel, and by cutting the threads at a certain length, there is obtained a sort of silver feather of glass. A thread of glass when red-hot, may be drawn or spun so fine as to be scarcely visible to the naked eye. It is almost perfectly elastic, and of course is one of the most sonorous bodies. Fluoric acid dissolves it at common temperatures, and alcalies at high degrees of heat. These are the only agents known which act upon it.

Glass utensils, unless very small and thin require to be gradually cooled in an oven. This operation is called *annealing*, and is necessary to prevent their cracking by change of temperature, wiping, or slight accidental scratches.

There are two toys made of unannealed glass, which though commonly used for the amusement of children, exhibit phenomena which justly interest the curiosity of the philosopher, we mean Prince Rupert's drop, and the Bologna flask, or philosophical phial.

Prince Rupert's drop is made by letting drops of melted glass fall into water; the drop assumes by that means an oval form, with a tail or neck resembling a retort. These drops are said to have been invented by Prince Rupert, and are therefore called by his name. They possess the singular property, that if a small portion of the tail is broken off, the whole bursts into powder, with a kind of explosion, and a considerable shock is communicated to the hand that grasps it. Their explosion in the dark is said to be attended with a flash of light, this however is a mistake; a flash of light indeed is produced if the drop be broken in a glass-receiver, but in that case the flash proceeds from the action of the projected particles, forcibly striking against the body of the glass, but no such phenomenon takes place if the drop be broken in free space.

The Bologna, or philosophical phial is a small cylindrical vessel of glass which has been suddenly cooled, open at the upper end, and rounded at the bottom. It is generally made so thick at the bottom, that it will bear a smart blow against a hard body without breaking; but if a little pebble or piece of flint is let fall into it, it immediately cracks, and the bottom falls into pieces.

REMARK...Concerning the cause of the phenomena of both these bodies, different opinions have been advanced. The most general is founded on the assumption that the dimensions of bodies which are suddenly cooled remain shorter than if the cooling had been more gradual. The dimensions therefore of the smooth external surface of these glasses, which are suddenly cooled, are supposed to be shorter than is adapted to the accurate envelopement of the internal part, which is necessarily cooled in a more gradual manner; if therefore by a crack or fissure, a solution of the continuity takes place in the external

coat, the sudden action of the parts which remained in a state of tension to recover that of perfect expansion, is supposed to effect the destruction of the mass.

Other philosophers again have been inclined to suspect that the phenomenon arises from a quantity of air being included in the substance of the glass which rushes suddenly out, if the surface which incarcerates it becomes broken. Mr. Lambert, on the contrary, maintains an opinion diametrically opposite to this: he supposes, that during the sudden cooling of the glass, vacuities are formed between its particles, and that they are sealed up by the smooth surface of the external covering, so that on the continuity of that surface being interrupted, the air suddenly rushing in occasions the bursting of the drop.

ALUMINE.

PART LIX.

SECT. I.

NATURAL HISTORY OF ALUMINE.

THIS earth derives its name from alum, of which it forms the base. It constitutes the lower strata of mountains and plains. It arrests the waters and causes them to rise in springs to the surface of the earth. It enters into the natural composition of the schistus, and all those stones and earths called argillaceous, such as *potter's-clay*, *fuller's-earth*, *lepidolite*, *mica*, *corundum*, &c. Hitherto it has not been found pure any where, except in the garden of the public schools at Halle in Germany.

PROPERTIES OF ALUMINE.

Alumine is white, and soft to the touch. It is insipid, adheres to the tongue, and occasions a sense of dryness in the mouth. When moistened with a small quantity of water it forms a tenacious, ductile, kneadable paste. When heated to redness it shrinks considerably in bulk, and at last becomes so hard as to strike fire with flint. After being ignited it is no longer capable of being kneaded with water into a ductile mass. It recovers however this property by solution in an acid and precipitation. Alcalies dissolve it in the humid way, and form com-

pounds decomposable by acids. It dissolves slowly in all acids. It possesses a powerful attraction for lime. The most intense heat of our furnaces is not able to melt it, but it becomes fusible when lime is added. Lavoisier has proved that it is capable of entering into a kind of fusion like paste, by the action of oxygen gas; it then cuts glass and resists the file. It absorbs water and carbonic acid from the atmosphere. By its mixture with water and silex it acquires great solidity. It does not unite with any combustible substance, but becomes fused into coloured frits with metallic oxids. Its specific gravity is 2. It is employed in a multitude of arts.

METHOD OF OBTAINING ALUMINE.

Take any quantity of alum of commerce, dissolve it in six parts of boiling distilled water, and add to this solution, when cold, liquid ammonia, till no further precipitate ensues. Then heat the whole nearly to the boiling point for a few minutes, and transfer it on a filter. In proportion as the fluid passes off, pour more water over the precipitate, until it passes tasteless. Let the precipitate obtained, while yet in a pasty state, be transferred into a glass or Wedgwood's bason, and add to it muriatic acid in small quantities at a time, until the whole is dissolved. Then evaporate the solution, till a drop of it, when suffered to cool on a plate of glass, yields minute crystals: on letting it now cool, crystals of alum will be deposited. Remove these crystals by decanting the fluid, and renew the evaporation, until, on further cooling, no more crystals are formed. Nothing now, but pure alumine remains in the solution; the fluid may therefore be decomposed by adding to it gradually liquid ammonia till no further precipitate ensues. The precipitate thus obtained when well washed and dried, is pure alumine.

REMARK...The process recommended in general by systematic writers for obtaining alumine differs from this; it consists in decomposing a solution of alum of commerce by an excess of a carbo-

nated alkali, washing the obtained precipitate, and exposing it to a sufficient heat to drive off the carbonic acid. This method however is imperfect, for if the alumine thus obtained be heated with charcoal, and a diluted acid is added to the mixture, sulphurated hydrogen gas will be liberated. It adheres to the tongue, and emits a peculiar odour when breathed upon. Sure signs that it is not pure.

It must be obvious that alumine cannot be obtained absolutely pure in this manner. For alum is a triple compound, consisting of alumine, potash, and sulphuric acid in excess. When this excess of acid is saturated, by adding to the solution an alkali, or even pure alumine, a highly insoluble salt (sulphate of alumine) is produced, differing from alum only in the proportion of its base. When we therefore gradually add to a solution of alum, a carbonated alkali, the first effect of the alkali is, to saturate the excess of the sulphuric acid, and the precipitate consists principally of the salt which is insoluble in water. A further quantity of the alkali effects instantly a decomposition of part of the salt, which, in proportion as it takes place, becomes mixed with the alumine; and it is thus covered from the further action of the alkali. This being the case it is obvious that no subsequent washing can do more than separate the sulphate of potash, and therefore the residuum, instead of being pure alumine, contains also a variable proportion of true sulphate of alumine; the sulphuric acid of which becoming decomposed on heating it in contact with charcoal, accounts for the sulphurated hydrogen gas produced by the affusion of an acid.

SECT. II.

EXPERIMENTAL PROOFS

OF

THE PROPERTIES OF ALUMINE.

EXPERIMENT I.

Alumine possesses a powerful attraction for lime.

THIS may be proved by agitating together fresh prepared lime-water and alumine. On separating the water by filtration it will be found to be totally deprived of the lime it held in solution.

EXPERIMENT II.

Alumine is soluble in liquid alcalies.

If one part of alumine be boiled for some time, with six of potash, soda, &c. in a sufficient quantity of water, a perfect combination will take place, which may be decomposed again either wholly or in part by the addition of an acid.

EXPERIMENT III.

Alumine combines with silex in the humid way.

If we mingle together a concentrated solution of alumine in potash, and a like solution of silex, and suffer the mixture to stand for a few hours, a precipitate takes place consisting of alumine and silex.

REMARK...This experiment proves that there exists a strong affinity between silex and alumine. Guyton de Morveau has been deceived in every instance of the affinities, which he attributes to the earths upon each other,* excepting in this case which has been observed before him by Chénévix.† He has attributed phenomena to substances which do not partake of it, but which resulted from the impurities of his re-agents.

EXPERIMENT IV.

Alumine, sulphur and charcoal form a compound which takes fire spontaneously in atmospheric air.

(Preparation of pyrophorus.)

In order to prepare pyrophorus, equal parts of powdered alum and brown sugar are melted over the fire, and are kept stirring, till reduced to dryness. The mixture is then to be finely powdered; and introduced into a common phial, coated with clay, to which a glass tube, open at each end, is luted, to allow the escape of the gases that are produced. The phial must then be set in the fire, surrounded by sand, in a crucible. Gas will issue from the open end of the tube, and may be inflamed by a lighted paper. When this ceases to escape, the crucible may be removed from the fire; and a little moist clay pressed down upon the open end of the tube, to prevent the access of air to the contents of the phial.

The pyrophorus thus formed is a black and very light powder, which instantly takes fire, when poured out of the bottle into the air; and inflames vividly in oxygen gas.

RATIONALE...The accension of pyrophorus is thus accounted for by Gren.‡ Part of the charcoal decomposes in a red heat part of the sulphuric acid of the sulphate of alumine, and becomes

* Ann. de Chem. XXXI. † Philosoph. Trans. May, 1802.

‡ Gren's Principles of Chemistry, vol. I. p. 256.

converted into carbonic acid gas, which escapes; the sulphuric acid is thus partly converted into sulphur, which sublimes and burns. During these changes, the potash, which is present in the alum of commerce, unites to part of the sulphur and forms with it a sulphuret of potash; and there remains the superfluous part of the coal that had been blended with the sulphate of alumine. The constituent parts of the pyrophorus are consequently exceedingly dry potash, sulphur, charcoal, and alumine. On exposure to air, the first rapidly attracts its moisture, and is heated with it. This heat is sufficient to inflame the sulphur, because sulphur is already, by its own nature, when combined with alkaline substances, by far more disposed to decompose oxygen gas. Lastly, this ignition of the sulphur in the pyrophorus is communicated to the coaly particles, that, at the beginning of its preparation, were mingled with the sulphate of alumine.

METHOD OF MAKING POTTERY.

Pottery or stone ware of all sorts, from the coarsest brown pitcher to the finest porcelain is made of alumine and silex. The use of the flint is to give strength to the ware, so that it may preserve its solidity during baking. In making the English stone ware, care is taken to employ only the fine parts of the alumine and chert, a species of flint. With this view the alumine is much beaten in water, by which the fine parts, being mixed with the fluid, are suspended, while the coarser sink to the bottom of the vessel. The thick liquid is further purified by passing it through hair and lawn sieves of different fineness; after this the liquid is mixed in various proportions for different wares, with another liquor of about the same density, and consisting of ground flints. The mixture is then dried in a kiln, and after being beaten to a proper consistence it becomes fit for being formed at the wheel, into dishes, plates, bowls, &c. When the ware has been exposed to heat for a certain time it is glazed, or is made to undergo a partial vitrification at the surface, without which it

would be pervious to fluids. Ordinary pottery is glazed with a semi-vitreous oxid of lead, or by throwing common salt over it in the furnace.

The yellow or queen's ware, is made of the same substances as the common flint ware, but in different proportions. The glazing is also different, it is made by mixing together in water to a consistence of cream, 112 parts of carbonate of lead, 24 parts of ground flint, and 6 of flint glass. The ware before it is glazed is baked in the fire, by which it acquires the property of strongly imbibing moisture; it is then dipped in this composition and quickly taken out. It is afterwards exposed a second time to the fire, by which means the glaze it has imbibed is melted, a thin glossy coat is formed upon its surface which is more or less yellow, according as a greater or less proportion of lead has been used. Porcelain, or china, is a semi-vitrified earthen ware of an intermediate nature, between common wares and glass. Chinese porcelain is said to be composed of two ingredients, one of which is a hard stone called *Petuntse*, which they carefully grind to a very fine powder; and the other, called by them *Kaolin*, is a white earthy substance, which they mix intimately with the ground stone. The former is of the siliceous, and the latter of the aluminous nature.

The manufacture of bricks is a coarser species of the same art,

GLUCINE.

PART LX.

SECT. I.

NATURAL HISTORY OF GLUCINE.

FOR the discovery of this earth we are indebted to Vauquelin who found it in 1795, in the Aigue-marine or beryl, a transparent stone of a green colour, and in the Emerald of Peru. It exists combined with silex, argil, lime, and oxid of iron in the one; and with the same earths, with oxid of chrome, in the other. It has lately been discovered in the Gadolinite by Mr. Ekeberg.*

Its name is taken from the Greek word (*γλυκύς*) which signifies sweet or saccharine, because it gives that taste to the salts it forms.

PROPERTIES OF GLUCINE.

Glucine is white, light, and soft to the touch. It is insipid and adheres to the tongue; and is infusible by itself in the fire.

* Journal des Mines, An. X. No. 20.

Its specific gravity is 2.967. It is soluble in alcalies and their carbonates, and in all the acids except the carbonic and phosphoric, and forms with them saccharine and slightly astringent salts. It is exceedingly soluble in sulphuric acid used to excess. It is fusible with borax, and forms with it a transparent glass. It absorbs one-fourth of its weight of carbonic acid. It decomposes sulphate of alumine. It is not precipitated by the hydrosulphurets nor by prussiate of potash, but by all the succinates. Its affinity for the acids is intermediate between magnesia and alumine.

METHOD OF OBTAINING GLUCINE.

To obtain glucine reduce some beryl to an impalpable powder, fuse it with three times its weight of potash, and dissolve the mass in muriatic acid. Separate the silex by evaporation and filtration, and decompose the remaining fluid by adding carbonate of potash; re-dissolve the deposit when washed in sulphuric acid, and by mingling this solution with sulphate of potash, sulphate of alumine will be obtained which crystallizes.

Then mix the fluid with a solution of carbonate of ammonia, which must be used in excess; filter and boil it, and a white powder will gradually fall down, which is glucine.

SECT. II.

EXPERIMENTAL PROOFS

OF

THE PROPERTIES OF GLUCINE.

*Although glucine resembles aluminē in many of its properties,
it possesses others which are different.*

EXPERIMENT I.

DISSOLVE separately equal quantities of glucine and alumine in nitric acid to perfect saturation. The salt which results from the combination of the glucine with nitric acid does not crystallize, but forms on drying, a kind of ductile paste; its taste is highly saccharine and afterwards astringent. The solution of this mass when mixed with tincture of galls produces instantly a brown-yellow precipitate.

On the contrary, the taste of the nitrate of alumine is not sweet, and its solution does not produce any precipitate with the same re-agent.

EXPERIMENT II.

To the solution of nitrate of glucine add some oxalate of potash, no change will take place even after some days.

On adding the same re-agent to nitrate of alumine a very copious white precipitate will be produced.

EXPERIMENT III.

Into a solution of nitrate of glucine let fall a solution of tartrate of potash, no change will be perceived.

On adding the same solution to nitrate of alumine, a flaky deposit will immediately be formed, and the super-natant fluid will be colourless.

EXPERIMENT IV.

On mixing a solution of nitrate of glucine with prussiate of potash, no change takes place.

On adding the same test to a solution of nitrate of alumine, a very copious white precipitate is obtained which becomes greenish at the end of some hours.

These experiments are sufficient to prove that glucine possesses peculiar properties, and that it is a distinct earth.

It is not yet known to what purposes glucine may be applied. If it should be discovered more abundantly hereafter, in combinations from which it can be easily separated, it may perhaps be employed for a variety of useful purposes in the arts, in chemistry, or medicine. The saccharine and slightly astringent taste of its saline combinations gives us reason to think that it possesses some salutary property, beneficial to animal economy.

ZIRCON.

PART LXI.

SECT. I.

NATURAL HISTORY OF ZIRCON, OR JARGON.

THIS earth was discovered in the year 1793, by Klaproth of Berlin, in the Zircon or Jargon, a gem first brought from the island of Ceylon, but also found in France, Spain, and other parts of Europe. Its colour is either grey, greenish, yellowish, reddish-brown, or purple. It has little lustre, and is nearly opaque. It is likewise found in another gem called the hyacinth. This stone is of a yellowish red colour mixed with brown. It possesses lustre and transparency.

PROPERTIES OF ZIRCON.

Zircon earth has a white colour, is exceedingly heavy, and rough or harsh to the touch like silex. It has neither taste nor odour, and is insoluble in water, but forms with it a kind of jelly.

It melts with borax into a transparent colourless glass. It suffers in a charcoal crucible a pasty fusion by intense heat, and contracts in its dimensions, acquiring a grey colour and scintillating hardness. In this state it is very hard and insoluble in acids. Its specific gravity is 4.3. Neither air nor combustible bodies act upon it. It is soluble in water, but retains while drying in the air a large quantity of it, which gives it the semi-transparency and appearance of a yellow jelly, or gum-arabic; it exhibits the same vitreous fracture. It unites with all the acids and forms salts, differing from those of the other bases by being decomposable by alumine, glucine, the alcalies, and by mere heat. It fuses with alumine and silex. It is insoluble even by boiling in a solution of alcalies, neither can it be fused with them by means of heat; but it is soluble in alkaline carbonates.

By these properties this earth may be distinguished from every other. It is still of no use in the arts.

METHOD OF OBTAINING ZIRCON.

Reduce the mineral to powder, mix it with three times its weight of potash, and fuse it in a crucible. Wash the obtained mass in distilled water, till the whole of the potash be extracted; then dissolve the residuum as far as possible in diluted muriatic acid. Boil the solution to precipitate any silex it may contain, filter it, and gradually add solution of potash. The zircon will now become precipitated. Wash it repeatedly in distilled water and dry it.

SECT. II.

EXPERIMENTAL PROOFS.

OF

THE PROPERTIES OF ZIRCON.

EXPERIMENT I.*Sulphuric acid and zircon unite readily.*

INTRODUCE zircon, gradually, into diluted sulphuric acid, until it dissolves no more when boiling hot. The salt which results from this combination is white, insoluble in water, and without any sensible taste. Heat decomposes it and leaves the zircon pure. It is not affected by acids, but alcalies and earths decompose it. Charcoal converts it, in a high temperature, into a sulphuret, which is soluble in water, and affords by evaporation crystals of hidro-sulphuret of zircon.

EXPERIMENT II.

Combination of nitric acid with zircon.

This combination may be effected in a similar manner to the last. It is impossible, however, to saturate the nitric acid with this earth, so as to destroy its acid properties, for the nitrate of zircon always changes the blue infusions of vegetables in the same manner as acids.

REMARK...Nitrate of zircon dissolves in a small quantity of water. To obtain it in a state of crystallization, it is necessary to evaporate it in a very gentle heat, or by simple exposure to the air.

The nitrate of zircon is decomposed,...1. by sulphuric acid, which forms with it a white precipitate, soluble in an excess of that acid; 2. by carbonate of ammonia, which produces in it a deposit, soluble in an excess of that salt; 3. by an infusion of galls in alcohol, a white precipitate is produced, soluble in an excess of the infusion. The greater part of the vegetable acids take zircon from the nitric, and form with it insoluble compounds.

EXPERIMENT III.

The muriatic acid unites readily with zircon, when in a state of extreme comminution, or when combined with carbonic acid.

This fact may be proved, by introducing zircon into muriatic acid in the usual manner, in either state.

REMARK...Muriate of zircon has no colour. Its taste is astringent. It is very soluble in alcohol, to the flame of which it does not communicate any particular colour. The muriatic acid is expelled by heat. This salt forms concretions in the mouth in consequence of being decomposed by the saliva. The solution of it affords, by a careful evaporation, small transparent needle-like crystals of a form difficult to be determined, which lose their transparency in the air, by giving out a portion of the water of crystallization.

Muriate of zircon is decomposed,...1. By sulphuric acid. A part of the sulphate of zircon which is formed, is precipitated in the form of heavy white flocks, while another portion is retained in solution by the muriatic acid. But if this acid be dissipated by heat, the remaining portion of the sulphate of zircon is gradually deposited, and if the evaporation of the liquor be stopped before that is reduced to dryness, it forms a kind of jelly, by

cooling. The sulphate of zircon is therefore soluble in muriatic acid; and this solubility is increased by means of caloric.

2. The phosphoric, citric, tartareous, oxalic, and sacco-lactic acids decompose the muriate of zircon, and form with its base insoluble compounds, which are precipitated in the form of white flocks.

3. The gallic acid precipitates the muriate of zircon, in the form of a white matter, (or in that of a greyish green, if it contains iron). The liquor in which the gallate of zircon has been formed preserves a greenish colour; and, though fresh quantities of gallic acid do not occasion any more precipitation, the carbonate of ammonia separates a very copious flocky matter, which has a purplish colour, similar to that of lees of wine.

These experiments prove,...1. That the gallic acid has a greater affinity with zircon than the muriatic acid possesses, and that the gallate of zircon is soluble in muriatic acid, since a part of it remained in solution in the liquor which was separated by carbonate of ammonia.

2. Carbonate of potash, saturated with carbonic acid, precipitates zircon from its solution in muriatic acid; and though this solution be made with effervescence, the precipitate, when washed and dried in the air, retains a large portion of carbonic acid, for this earth afterwards produces a lively effervescence, when dissolved in acids.

3. A solution of sulphurated hydrogen gas in water, mixed with a solution of zircon (containing iron) disturbs the transparency of the solution, and gives to it a reddish colour; but it does not occasion a true precipitate. The hidro-sulphuret of ammonia instantly precipitates this salt of a beautiful green colour, which becomes black when dry. This precipitate when placed on burning coals, gives out the smell of sulphurated hydrogen gas, and becomes of a bluish, or slightly purplish colour by pulverization; before it has been heated it affords a powder of a pearl grey colour. This colour is owing to the oxid of iron combined with the zircon.

4. The carbonate of ammonia produces at first a deposition in muriate of zircon, but fresh quantities of ammoniacal salt redissolve the greater part of the precipitate. In this case a triple salt is formed, which may be decomposed by heat.

5. The prussiate of mercury produces in the solution of muriate of zircon, a very copious precipitate, soluble in muriatic acid. The deposition cannot be owing to the combination of the mercury with the muriatic acid, for none of the salts into which it enters form a precipitate with the prussiate of mercury. Were we even to suppose this case to be an exception, still the deposition would not be soluble in simple muriatic acid.

6. A plate of zinc, introduced into a solution of muriate of zircon, occasions a slight effervescence, owing to the disengagement of hidrogen gas. The liquor becomes milky, and at the end of some days assumes the form of a white semi-transparent jelly.

7. Pure alumine decomposes the muriate of zircon, by the assistance of a slight heat. The alumine is dissolved, the liquor becomes milky, and assumes a gelatinous form in cooling. When the muriate of zircon contains iron, it remains in solution with the alumine, so that the zircon which is precipitated does not contain any sensible quantity of that metal....See *Klaproth's Beiträge. Vauquelin, Ann. de Chem: Tom. xxii. p. 179.*

AGUSTINE.

PART LXII.

NATURAL HISTORY OF AGUSTINE.

THIS is a new earth discovered in the Saxon Beryl, or Beryl of Georgien Stadt, a stone greatly resembling the Beryl of Siberia, by professor Tromsdorff of Erfurth in Germany,* to which he has given the name of agustine on account of the property of forming salts which are nearly destitute of taste.

PROPERTIES OF AGUSTINE.

Agustine is white and insipid; when moistened with water it is somewhat ductile, but is not soluble in that fluid. Exposed to a violent heat, it becomes extremely hard, but acquires no taste. It combines with acids, forming salts, which have little or no taste. It does not combine either in the humid or dry way with alcalies, or with their carbonates. It retains carbonic acid but feebly. It dissolves in acids equally well after having been hardened, by exposure to heat, as when newly precipitated. With sulphuric acid it forms a salt which is insipid, and scarcely soluble, but an excess of acid renders it soluble, and capable of crystallizing in stars. With an excess of phosphoric acid it forms a very soluble salt. With nitrous acid it forms a salt scarcely soluble.

* Ann. de Chemie, xxxiv. 133.

YTTRIA.

PART LXIII.

NATURAL HISTORY OF YTTRIA.

THE discovery of this new earth in a fossil, termed by Gadolin Ytterby, from the place where it was found, has lately been confirmed by Vauquelin and Klaproth.

PROPERTIES OF YTTRIA.

Yttria is the heaviest of the earths. Its specific gravity is 4.842. It resembles glucine in several of its properties. It is smooth and insipid. It is infusible alone, but vitrifies with supersaturated borate of soda. It combines with the acids, and is precipitated from those solutions by ammonia and prussiate of potash. It is also precipitated by tannin. The precipitate is not soluble in acetic acid. As some of its salts are coloured, and its weight nearly approaches to that of metals, it is considered as the link which connects the metals with the earths. It differs from glucine in not being soluble in fixed alkalies, nor being precipitated by the succinates. Its attraction for the acids is also in general stronger than that of glucine, and its saline compounds have not the same saccharine taste. Its other properties have not yet been examined.

MAGNESIA.

PART LXIV.

SECT. I.

NATURAL HISTORY OF MAGNESIA

THIS earth is not found pure in nature, but is obtained by art from some of its combinations. It gives a peculiar character to the substances of which it forms a part. The stones which contain magnesia in considerable quantity, have generally a smooth and unctuous feel, a greenish cast, a fibrous or striated texture, and a silky lustre. Among them we may mention *talc*, *steatite*, *serpentine*, *chlorite*, *asbestos*, *actynolite*, *jade* or *nephritic stone*, *baikalite*, *boracite*, &c. It is likewise found neutralized with various acids. It has been discovered by Vauquelin, in several sea-plants.*

PROPERTIES OF MAGNESIA.

Pure magnesia does not form with water an adhesive ductile mass. It is in the form of a very white spongy powder, soft

* Ann. de Chemie. xviii, 78.

to the touch, and perfectly tasteless. It is very slightly soluble in water. It absorbs carbonic acid gradually from the atmosphere. It changes very delicate blue vegetable colours to green. Its attraction to the acids is weaker than those of the alcalies. Its salts are partially decomposed by ammonia, one part of the magnesia being precipitated, and the other forming a triple compound. Its specific gravity is about 2.3. It is infusible even by the most intense heat; but when mixed with some of the other earths it becomes fusible. It combines with sulphur. It does not unite to phosphorus or carbon. It is not dissolved by alcalies in the humid way. When heated strongly it becomes phosphorescent. With the dense acids it becomes ignited. With all the acids it forms salts of a bitter taste, mostly very soluble.

METHOD OF OBTAINING MAGNESIA.

The usual method of procuring magnesia, is to precipitate it from sulphate of magnesia by means of an alcali.

To effect this dissolve any quantity of sulphate of magnesia in a large quantity of distilled water and add to it gradually a solution of perfectly pure carbonate of potash, or soda, till no more precipitate ensues. Then collect the precipitate on a cloth and boil it repeatedly in a large quantity of distilled water, till this fluid passes perfectly tasteless. It is then to be dried, and exposed in a crucible to a red heat, till a sample of it, when cold, does not occasion the least effervescence with acids.

RATIONALE...In this process a double decomposition takes place, the sulphuric acid of the sulphate of magnesia combines with the alcali, and forms sulphate of potash; and the carbonic acid of the alcali joins to the disengaged magnesia, and forms carbonate of magnesia; the latter is precipitated, and the sulphate of potash remains in solution. On exposing the carbonate of magnesia to heat, the acid is expelled and the magnesia is left behind in a pure state.

SECT. II.

EXPERIMENTAL PROOFS
OF
THE PROPERTIES OF MAGNESIA.

EXPERIMENT I.

Magnesia converts vegetable blues into green.

MIX one part of magnesia with six of water, shake the mixture for a few minutes, and then separate the water by filtration. If this water be mingled with a pale blue mixture of cabbage, the fluid will instantly become green.

Magnesia resembles in this respect the alcalies, and hence it has been classed by some chemists amongst these bodies. It seems to form the link which unites the earths with the alcalies.

EXPERIMENT II.

Magnesia does not form an adhesive mass with water.

If magnesia and water be mixed together, no adhesive or ductile mass can be obtained. It is capable however of retaining this fluid very obstinately; for if 100 parts of magnesia are thrown into water and then dried, its weight is increased to about 118.

EXPERIMENT III.

Magnesia attracts carbonic acid from the air.

If any quantity of magnesia be exposed to the air for some time it soon attracts carbonic acid, which may be proved by pouring on it an acid, which causes a slight effervescence.

EXPERIMENT IV.

Carbonic acid has a stronger affinity for lime than for magnesia.

This may be evinced by digesting carbonate of magnesia in fresh prepared lime-water. The lime will attract the carbonic acid from the magnesia and be rendered insoluble. Hence the taste of lime-water is totally destroyed by carbonate of magnesia.

EXPERIMENT V.

Ignition of magnesia by the affusion of sulphuric or nitric acid.

This experiment has been noticed already, vol. I. page 134.

EXPERIMENT VI.

Magnesia combines with sulphur.

See vol. I. page 152.

The other properties of this earth require no experimental investigation.

ALCALIES.

ALCALIES.

PART LXV.

WE consider these substances (one of them excepted) as simple bodies, though several chemists have asserted that they are compound; others have even endeavoured to prove this by experiment, but none of their proofs are yet satisfactory.

Were we permitted to judge from analogy we should be inclined to suppose that all alcalies possess one common base, for they have a great number of properties which are common to them all. We have indeed seen that one (ammonia) has been decomposed; we have proved that nitrogen enters into its composition, (see vol. I. p. 314, &c.) but no conclusion can be drawn from this. We are therefore forced to consider the rest of them as simple bodies, till future discoveries remove the veil which at present obstructs our view.

ENUMERATION OF ALCALIES.

BARYTES,
POTASH,
SODA,
STRONTIA,
LIME,
AMMONIA.

GENERAL PHYSICAL PROPERTIES OF ALCALIES.

All alcalies are incombustible, and soluble in water; they possess an acrid, urinous taste. When mixed with siliceous substances and exposed to an intense heat, they form a more or less perfect glass. They unite with another class of bodies called acids, and form new compounds, in which both the acid and alkaline properties are more or less lost. They render oils miscible with water. They change various blue vegetable pigments to green; red to violet or blue; and yellow to brown. Blue pigments that have been turned red with acids are again restored by alcalies to their primitive colours. They emit light on the affusion of the dense acids when freed from water. They attract water and carbonic acid from the atmosphere. They unite to sulphur by fusion and by means of water. They exert a great solvent power on the cellular membrane and animal fibre; they also corrode woollen cloth, and if sufficiently concentrated convert it into a sort of jelly.

BARYTES,

PART LXVI.

SECT. I.

NATURAL HISTORY OF BARYTES.

BARYTES does not exist pure in nature. It is always found in combination with sulphuric or carbonic acid. United with the sulphuric acid, it forms the mineral called *sulphate of barytes*, or *baroselenite*. It is found in Staffordshire, Derbyshire, &c. When united to carbonic acid it is called *ærated barytes*, or *carbonate of barytes*, found at Anglezark, near Chorley in Lancashire. Both combinations are met with regularly crystallized and amorphous.

PROPERTIES OF BARYTES.

Pure barytes has a stronger affinity than any other body for sulphuric acid; it turns blue tincture of cabbage green. It is entirely infusible by heat alone, but melts when mixed with various earths. Its specific gravity is 4.000. It changes quickly in the air, swells, becomes soft, and falls into a white powder with the acquisition of about one-fifth of its weight. This slaking is much more active and speedy than that of lime. It combines with phosphorus, which compound decomposes water rapidly. It unites to sulphur by the dry and humid way. It has

a powerful attraction for water, which it absorbs with a hissing noise and consolidates it strongly. It is soluble in twenty times its weight of cold, and twice its weight of boiling water. Its crystals are long four-sided prisms of a satten-like appearance. It is a deadly poison to animals.

METHOD OF OBTAINING BARYTES.

1. Take native carbonate of barytes, reduce it to a fine powder and dissolve it in a sufficient quantity of diluted nitric acid, evaporate this solution till a pellicle appears, and then suffer it to crystallize in a shallow basin. The salt obtained is nitrate of barytes; expose this nitrate of barytes to the action of heat in a china cup, or silver crucible, and keep it in a dull red heat for at least one hour, then suffer the vessel to cool, and transfer the greenish solid contents, which are pure barytes, into a well stoppered bottle. When dissolved in a small quantity of distilled water and evaporated, it may be obtained in a beautiful crystalline form.

RATIONALE...The nitric acid added to the native carbonate of barytes unites to the barytes, and expels the carbonic acid and forms nitrate of barytes; on exposing this nitrate to heat, it parts with its nitric acid, which becomes decomposed into its constituents, leaving the barytes behind.

2. Pure barytes may likewise be obtained from its sulphate. For this purpose boil powdered sulphate of barytes in a solution of twice or three times its weight of carbonate of potash, in a Florence flask for about two hours, filter the solution, and expose what remains on the filter to the action of a violent heat.

RATIONALE...In this case the sulphuric acid of the barytes unites to the potash, and the carbonic acid of the latter joins to the barytes; hence sulphate of potash and carbonate of barytes are obtained. The former is in solution and passes through the filter; the latter is insoluble and remains behind. From this artificial carbonate of barytes, the carbonic acid may be driven off by heat.

SECT II.

EXPERIMENTAL PROOFS

OF

THE PROPERTIES OF BARYTES.

EXPERIMENT I.

Barytes changes blue vegetable colours green.

LET fall into a wine glass full of distilled water, rendered slightly blue by the admixture of tincture of cabbage, a few grains of barytes. The blue colour of the fluid will instantly be converted into a lively green.

EXPERIMENT II.

Barytes changes red vegetable colours violet.

If in a similar manner to water rendered red by tincture of brazil wood, a small quantity of barytes be added, the red colour will be changed into a violet.

EXPERIMENT III.

Barytes changes yellow vegetable colours brown.

Let paper, stained yellow with an infusion of turmeric, be dipped into a solution of barytes, it will soon lose its yellow colour and become brown.

EXPERIMENT IV.

Barytes renders oils miscible with water.

If one part of oil of olives be put into a phial and agitated together with three of a concentrated solution of barytes, a saponaceous mass will be obtained diffusible in water.

EXPERIMENT V.

Barytes gives out heat on being united to water.

If fresh-prepared barytes be sprinkled with water it gradually swells up and bursts, it solidifies the water, and becomes considerably heated. If a little more water be gradually added it hardens with it; and, if left for some time undisturbed, becomes so hard that it forms a kind of cement: a still larger addition of this fluid changes it into a white powder exceedingly voluminous, and soluble in water.

EXPERIMENT VI.

Barytes forms glass with silex.

Put a few grains of silex and double the quantity of barytes on a piece of charcoal, urge it well with heat by means of the blow-pipe. The mixture will melt and a globule of glass will be obtained.

EXPERIMENT VII.

Barytes has a strong attraction for carbonic acid.

Let a solution of barytes be exposed to the air, it will soon acquire a pellicle, like lime-water, which after some time sinks to the bottom of the vessel.

Or, mix a little water impregnated with carbonic acid, with a solution of barytes, the mixture will immediately become turbid, and a precipitate will be obtained, which in both cases is carbonate of barytes, originating from the union of the carbonic acid and the barytes.

EXPERIMENT VIII.

Barytes tinges the flame of burning alcohol yellow.

Put a little barytes into a silver spoon, pour over it strong ardent spirit, and set fire to it with a taper; the spirit will burn with a yellow flame, which will be more perceptible by heating the mixture over a candle during its burning.

EXPERIMENT IX.

Barytes disengages sulphuric acid from all its combinations.

Dissolve a grain of sulphate of soda in a wine glass full of distilled water, and add to it a few drops of a solution of barytes, white clouds will instantly be formed, and an insoluble precipitate will be gradually deposited.

RATIONALE...In this case the barytes unites to the sulphuric acid of the sulphate of soda, and forms with it sulphate of barytes which is one of the most insoluble substances that chemis-

try presents, requiring for solution about 43000 times its weight of water.

REMARK...Barytes having a strong affinity for sulphuric acid, any other combination of that acid may be made use of instead of sulphate of soda.

The solution of barytes, or its combinations with nitric, muriatic, or acetic acid, are therefore very excellent tests for detecting the presence of sulphuric acid. It is consequently a very important re-agent in practical chemistry.

EXPERIMENT X.

Barytes is very soluble in water, and shoots on cooling into regular crystals.

Take barytes, obtained in either of the processes mentioned before, put it into a Florence flask, and pour on some distilled water; boil the solution briskly till a strong pellicle appears, then filter it boiling hot through colourless bibulous paper, freed from size, and let the solution cool in a corked phial. It will shoot into regular crystals, which if the evaporation has been carefully conducted, have the form of four-sided prisms of a brilliant and satin-like appearance.

REMARK...These crystals are barytes in a state of absolute purity. They are so soluble as to be taken up again, when heated, merely by their own water of crystallization. When exposed to a strong heat, they swell and foam, and leave a dry white powder. At 60° an ounce of water dissolves only 25 grains of them.

POTASH.

PART LXVII.

SECT. I.

NATURAL HISTORY OF POTASH.

IF wood or vegetables be burnt in the open air, and the ashes repeatedly washed with water till it passes tasteless, and if this liquid be evaporated to dryness, the substance which remains is called *potash*; far however from being in a state of purity. In this state it occurs in commerce.

It is seldom found in an uncombined state, except in wells in towns, as at Douay, &c. It is said to exist in the aluminous ore of La Tolfa. In combination with the sulphuric, nitric, and muriatic acids, it is found in Spain and in the East Indies.

Potash was formerly denominated the vegetable alcali, but improperly, because it is met with abundantly in mineral bodies, more especially in volcanic products. Dr. Kennedy has lately discovered it in the pumice stone. Vauquelin has found it in the Zeolite from the Ferro islands. Klaproth has likewise discovered it in the *Leucite*, an earth of the siliceous genus.

Vegetable physiologists are not agreed whether potash be derived from the soil in which vegetables grow; whether it exists uncombined with any acid in plants; whether it be a product of vegetation; or whether it be generated during the process of burning.

Potash was for a long time unknown in its pure state, because it was difficult to obtain it. We shall examine its properties in that state, and then point out the methods of obtaining it.

PROPERTIES OF POTASH.

Potash, in a crystallized form, consists of soft quadrangular compressed prisms, which are extremely caustic, and deliquescent. It dissolves all soft animal matters when brought into contact with it. It liquefies by a gentle heat, and rises in fumes at high temperatures. It does not unite in a direct manner with phosphorus. It easily combines with sulphur and metallic oxids. It dissolves alumine in the humid way, and even a small quantity of silex; but it does not act on glucine or zircon, nor on magnesia or lime. It contracts no union with barytes. It absorbs water and carbonic acid rapidly. It fuses into glass with silex by the aid of fire. It forms salts which in general do not yield their acid unless to barytes. It changes blue vegetable colours green, and possesses all the general properties of alcalies.

METHODS OF OBTAINING POTASH.

It has long been a desideratum with chemists to possess a method of preparing potash in a state of absolute purity; the strong tendency which it has to combination renders this extremely difficult. The following are the methods now made use of.

1. Bouillon la Grange's apparatus* consists of several boxes of common deal. At the bottom put river-sand, which must be well washed, and over it add another stratum, but of a finer kind, and cover the whole with a cloth, besprinkled with wood-ashes. In the bottom of each box a hole is made, into which is

* La Grange's Manual of Chemistry, vol. i. p. 172.

fitted a glass tube, for the purpose of affording a passage to the liquor as it filters through the sand.

Having arranged the apparatus in this manner, take equal parts of quick-lime and potash of commerce, if the lime is very caustic; but in the contrary case, it requires twenty parts of lime to fifteen of potash: put water into an iron kettle, bring it nearly to a state of ebullition, and then add lime, which by its slaking will bring the water to that state completely. When it is slaked mix the potash, and form of the whole a thick liquid, which must be suffered to cool a little. Then pour the mixture into the boxes, and immediately throw water over it; but to prevent the water from making holes, when added, place over it a small board, which will rise with the water.

Care must be taken to place earthen pans, or other vessels, to receive the liquor which runs through the tubes; and, that the ley may not absorb carbonic acid from the atmosphere, the vessels must be closed with care, in such a manner as to exclude the external air. It will be necessary also to keep water always over the mixture, which must be collected till it passes tasteless from the tubes.

The liquors obtained are nearly of the same degree of strength till towards the end of the process; when they grow weak suddenly.

To evaporate the water, use should be made of cast-iron pots, beginning with the last portions, which are a little weaker; and to prevent the necessity of keeping the strongest a long time in contact with the air when boiling, a strong ebullition is requisite. When the fluid is concentrated to a certain degree, any sulphate of potash that may be present will crystallize, and be precipitated.

To obtain dry potash, pour the concentrated liquor into a small bason, and proceed with the evaporation, till a little of it poured on an iron plate, or a marble slab, becomes solid.

Then put the concrete potash into a jar, and pour over it very strong alcohol; the potash alone dissolves in it; the sulphate and

muriate of potash, with the portions of earth and even of carbonic acid, which it obstinately retains, or which it may have acquired from the air during the evaporation, remain at the bottom of the solution. Afterwards decant the pure liquor, and distil it in a retort till it becomes colourless. It must then be evaporated in a silver bason. On cooling, it crystallizes in white laminae, which are sometimes three-tenths of an inch in length: or, instead of suffering it to crystallize it may be evaporated to dryness.

2. Lowitz has given another method.* According to this chemist the whole of the operation for obtaining potash of the greatest purity, and without the least colour, consists in this: A lixivium of potash, freed from carbonic acid in the usual manner, is evaporated to a thick pellicle. After the cooling, the foreign salt which has crystallized is to be separated, and the evaporation of the lixivium continued in an iron pot. During this second evaporation the pellicle of foreign salts, particularly of carbonate of potash, which continues to be formed, must be carefully taken off with an iron skimmer. When no more pellicle is formed, and the matter ceases to boil up, it is removed from the fire and suffered to cool, continually stirred with an iron spatula. It is then to be dissolved in double the quantity of cold water, and the solution filtered, and evaporated in a glass retort, till it begins to deposit regular crystals. If the mass should consolidate ever so little by cooling, a small quantity of water is to be added, and it must be heated again to render it fluid. After the formation of a sufficient quantity of regular crystals, the fluid, which is very brown, is to be decanted, and the salt, after being suffered to drain, must be re-dissolved in the same quantity of water. The decanted fluid must be kept in a well-closed bottle, and suffered to become clear by subsiding during several days. It must then be decanted for a second evaporation and crystallization. The process must be repeated as long as the crystals af-

* Nicholson's Journal, vol. i. p. 14.

ford, with the least possible quantity of water, solutions perfectly limpid. These solutions are to be preserved in well-closed bottles, to defend them from the access of air.

The greatest difficulty of this process arises from the facility with which the fluid assumes a solid form. To obviate this inconvenience, a small portion of it may be concentrated to the point at which it becomes converted into a solid mass by cooling. The saturation of a lixivium considerably evaporated may be ascertained by throwing small pieces of this mass into it during its cooling. When these are no longer dissolved, it is a proof that it is at the required point.

With regard to the foreign salts which are mixed with the potash, the greatest portion separates by crystallization after the first evaporation. The rest is separated during the second concentration by the continual skimming of the pellicle. The little which may remain with the potash must precipitate for want of water of solution, in a lixivium, wherein the alkali itself is no longer dissolved but by its own water of crystallization.

REMARKS.

The property of alkalies to dissolve in highly rectified alcohol, with the exclusion of every foreign salt, would afford an excellent means of obtaining potash very pure, if their mutual action did not afford a new source of impurity. For when an alkali absolutely pure and crystallized is dissolved in spirit of wine, even without heat, the fluid assumes a very brown colour, which becomes still deeper after being decanted from the saline mass.

The crystallization of potash is very different, accordingly as the crystals are formed with cold or heat. In the first case, the crystals obtained are octahedra in groups, which contain 0.43 water of crystallization, and excite by their solution in water, even in the summer, a degree of cold very near the point of aqueous congelation. In the second case, very thin crystalline transparent blades of extraordinary magnitude are formed, which

by an assemblage of lines, crossing each other in infinite directions, present an aggregate of cells or cavities, most commonly so perfectly closed that the vessel may be inverted without the escape of the smallest drop of the lixivium, though sometimes included to the amount of an ounce or two. For this reason, it is necessary to break this fine crystallization, that the fluid may run off. The crystals present in their regular formation rectangular tetragonal blades, which as they contain little water of crystallization, produce a considerable degree of heat when dissolved in water.

By exposing such alkaline crystals to a red heat in a silver crucible, they become fused; and, after cooling, afford a mass as white as snow, extremely caustic and deliquescent.

As the crystals and the lixivium, during the length of time required to drain the salt, may frequently become charged with a portion of carbonic acid, it is advisable, in order to avoid this inconvenience as much as possible, that the lixivium, as soon as it is brought to the requisite point of concentration, should be poured into a narrow-necked bottle, and well closed therein to crystallize. After the crystals are formed, the bottle is to be reversed without opening, and kept at a temperature rather warm until the crystals are well dried. During the winter, the liquor, after the first crystallization, continues to crystallize without being submitted to a new evaporation, provided only that it be exposed to a temperature somewhat colder than that wherein the first crystals were formed.

SECT. II.

EXPERIMENTAL PROOFS

OF

THE PROPERTIES OF POTASH.

EXPERIMENT I.

Potash rapidly absorbs water and carbonic acid from the atmosphere.

IF potash be exposed to the air in an open vessel, it soon attracts humidity and carbonic acid, augments in weight, becomes liquid, and gradually assumes the state of liquid carbonate of potash. To preserve it in a state of purity it must therefore be kept in bottles well stopped and entirely filled with it.

REMARK...When dry, or fused potash is dissolved in water, it first absorbs a certain quantity which it solidifies, caloric is evolved, and then the potash dissolves in the excess of water which is added. The absorption of water by potash is therefore really a combination in consequence of the affinity it exercises, and is very different from the simple extension of a salt in a liquid by solution; this is the reason why sensible caloric is evolved from potash and water, and the rest of the alcalies.

This effect does not take place but when the alcalies are in a dry state, or freed from the water of crystallization; for if they are in a crystallized state when added to the water, *cold* is produced, because there is no water to be solidified. A solid then passes into a state of liquidity. This we have considered already more circumstantially under the article Heat.

EXPERIMENT II.

Potash combines with silex in the dry way.

If potash and silex are fused together, a combination is obtained known under the name of glass. This product differs according to the quantities of silex and potash of which it is composed.

If three or four parts of potash be fused with one of silex, the result will be a soft brittle kind of glass, which is soluble in water. This solution is called liquid siliceous potash, or improperly liquor of flints.

To prepare this liquid, take one part of silex, reduced to a fine powder (or pure sand) and three or four parts of potash; put these two substances into a crucible which must be only half filled, and place the crucible in the fire. As soon as the matter enters into fusion, it puffs up considerably, and continues to swell till the alkali has dissolved the silex. The crucible is to be kept uncovered as long as the effervescence lasts, but when it is over, cover the crucible and augment the heat till the whole fuses quietly. The contents are then poured out on a dry iron plate or stone, the matter as it cools becomes hard and assumes the appearance of glass. This matter, when pulverized and dissolved, by pouring water over it, forms liquid siliceous potash. It is decomposable by acids, and pure siliceous earth may be obtained from it in that way as mentioned before.

EXPERIMENT III.

Potash acts very powerfully upon animal substances.

Immerse a slip of woollen cloth, or a piece of muscular flesh into a concentrated solution of potash, the animal substance will soon become destroyed, and form with the potash a homogeneous compound.

EXPERIMENT IV.

Potash has a strong affinity for sulphur.

When equal parts of potash and sulphur are triturated together in a glass mortar, the sulphur soon acquires a green colour, the mass becomes pasty, its temperature is raised, and a sulphuret of potash is obtained.

EXPERIMENT V.

Potash and snow produce a great degree of cold.

When four parts of crystallized potash reduced to powder, and three of uncompressed snow, are hastily mingled together, the mixture becomes fluid, and an intense degree of cold is produced, which under proper circumstances is — 51° Fahr.

EXPERIMENT VI.

Potash and dense acids produce a great degree of heat.

If equal weights of potash freed from its water of crystallization by fusion, and dense sulphuric acid are mingled together, a great degree of heat will be instantly produced, and a flash of light will be seen to pervade the mixture if the experiment be made in the dark.

SODA.

PART LXVIII.

SECT. I.

NATURAL HISTORY OF SODA.

THE name of soda is given to the next alcali, which greatly resembles potash. Hitherto we are not better acquainted with the nature of soda than with that of potash, being equally uncertain whether it previously existed ready formed in the vegetable; or if it be a combination of certain radicals effected during the process for obtaining it.

Soda frequently occurs in the mineral kingdom, united with sulphuric, muriatic, and boracic acids; it is also found in large quantities in Egypt, combined with carbonic acid. It appears to be deposited in large impure masses, under the surface of the earth, in various countries, from which it is extracted by running water. Thus it is found after the spontaneous evaporation of the water, mixed with sand in the bottom of lakes in Hungary; in the neighbourhood of Bilin in Bohemia; and in Switzerland. It occurs also in China, and near Tripoli in Syria, Egypt, Persia, and India. It frequently oozes out of walls and crystallizes on their surface.

PROPERTIES OF SODA.

Soda differs particularly from potash by the following properties. In the fire it is rather more fusible. When exposed to the contact of the air it attracts water and carbonic acid, but it does not liquefy like potash, it merely acquires a pasty consistence, and at last crumbles into powder. It is not altered by light. It attracts sulphur and sulphurated hydrogen more feebly. It adheres less strongly to the acids. It fuses and dissolves alumine more easily. All its other properties, its volatilization by a very high degree of heat, its acrid causticity, its solubility, its combinations with sulphur, &c. resemble those of potash.

METHOD OF OBTAINING SODA.

Soda like potash is procured by lixiviation from the ashes of burnt plants, but only from those which grow upon the sea shores. The variety of plants employed for this purpose is very considerable. In Spain, soda is procured from the different species of the *salsola salicornia* and *batis maritima*. The *zostera maritima* is burnt in some places on the borders of the Baltic. In this country we burn the various species of *fuci*; and in France they burn the *chenopodium maritimum*.

The soda thus procured is more or less pure according to the nature of the particular plant from which it is obtained. The greatest part however is a true carbonate of soda.*

In order to obtain it in a state of purity the carbonate of soda must be treated like potash of commerce with lime and ardent spirit, as described before.

REMARK...It is curious that some plants, which in their native soil yield only potash, afford also soda if they are cultivated in the neighbourhood of the sea, or on land occasionally inundated by it.

* The methods of preparing soda for the English market, we have stated in Nicholson's Journal, for August, 1802.

SECT. II.

EXPERIMENTAL PROOFS

OF

THE PROPERTIES OF SODA.

EXPERIMENT I.

Method of distinguishing soda from potash.

LET fall into a solution of the alkali to be investigated, a few grains of oxalic acid; for this acid forms with potash oxalate of potash, which is very soluble, and on the contrary with soda it produces oxalate of soda, which is of a very difficult solubility.

EXPERIMENT II.

Formation of soap.

The combination of soda or potash, with oils, or fat in general, forms the compound called *soap*. The union of oil, &c. with potash, affords those called *soft soap*; the combination of soda with the same substances affords those called *hard soap*. It seems to be an established truth that potash combined with any kind of fat can only afford a soap, to which no cooling can give

a hard consistency. The addition however of a certain quantity of soda, or even muriate of soda will produce the effect of consolidating it. The formation of white *soap* may be shown in the following manner :

Let one part of lime (previously slaked) and two of carbonate of soda be boiled in twelve parts of water for half an hour, filter the lixivium through a linen cloth (pouring back the fluid upon the cloth till it passes clear) and evaporate it till its specific gravity be about 1.375, or which is the same thing, till a phial which would contain one ounce of water, will hold an ounce and three eighths of the fluid ; this having been done, soap may be made by mere mixture of this ley with olive oil, in the proportion of one part of the former with two of the latter, in a glass or stone-ware vessel. This mixture being beat up from time to time with a wooden spatula, soon becomes consistent, and if left to stand for four or five days, it forms a white hard soap.

REMARK...In large manufactories the ley for making soap is made no stronger than to float a new laid egg, when the workmen begin to form the mixture. The oil or tallow is first boiled with a weak ley until the whole is formed into a saponaceous compound. It is then kept boiling with a stronger ley until it acquires a considerable consistence, and seems to be separating from the fluid below. This separation is a very material part of the operation ; and to effect it completely, a quantity of common salt is added, the materials are continually boiled for three or four hours, and then the fire is withdrawn. The soap will now be found united at the top of the liquor, or what is called the *waste-ley*, which is of no further use, and is therefore drawn off. The soap is now melted for the last time with a ley, or even with water, it is then allowed to cool for a short time, and afterwards cast into wooden frames. The last melting is of considerable importance, as it gives the soap a compact appearance.

The tallow for making soap is reckoned good if 13cwt. yield a ton of white soap.

Mottled soap is made in a similar manner as the last, the mottled appearance is given towards the end of the operation of boiling, by dispersing the ley through the soap, or by adding to it a quantity of a solution of sulphate of iron, which by its decomposition, deposits its oxid through the soap, and gives it an appearance of blue marble. In some manufactures the black oxid of manganese is made use of for the same purpose.

Yellow soap is made with tallow and resin; and these are reckoned good, if 10 cwt. of tallow, and $3\frac{1}{2}$ cwt. of resin with the proper quantity of soda afford a ton of soap.*

Soap of wool may be made by boiling shreds of woollen cloth of any kind, with ley, till the whole has acquired a certain consistence, This kind of soap has been made and applied with success,† in several manufactures in France.

An ammoniacal soap may be produced, by pouring a concentrated solution of muriate of ammonia into a solution of common soap.

A soap of lime, barytes, and strontia, may be formed, by pouring solutions of these alcalies into that of common soap. These, together with the following terrene soaps, are insoluble, and possess no detergent properties.

Amongst the earthy soaps those of magnesia and alumine are the principal. Soap of magnesia is produced by mingling a solution of common soap with a solution of sulphate of magnesia. Soap of alumine is obtained by adding to a solution of soap a solution of alum of commerce.

* Nicholson's Journal, 4to edition, 1779, No. xxviii, p. 103.

† Ann. de Chimie. xxi, 27.

STRONTIA.

PART LXIX.

SECT. I.

NATURAL HISTORY OF STRONTIA.

STRONTIA was for some time confounded with barytes. Indeed a great many of its properties are so similar to it, that every thing which has been said of the latter will apply to strontia. It approaches to barytes as soda approaches to potash. Klaproth and Dr. Hope, in the year 1793, were the first who established its peculiar nature.

Strontia exists in a fossil state, and was first discovered at *Strontian*, in Argyllshire in Scotland, from whence it takes its name. It is found united to carbonic acid, forming what is called carbonate of strontia. This mineral is somewhat transparent, but it has in general a yellow, or greenish tinge. Combined with sulphuric acid, it constitutes the mineral called sulphate of strontia. This fossil is of a reddish or flesh colour; it has been found lately by Mr. Clayfield, in the vicinity of Bristol, and has also been met with in Pennsylvania.

PROPERTIES OF STRONTIA.

Strontia in a state of purity has a caustic taste, it changes blue vegetable colours green, and unites oil with water. It at-

tracts carbonic acid strongly from the atmosphere, becomes slaked and swells up. It heats much and hardens strongly with water. It is not fusible by the blow-pipe, but becomes extremely phosphorescent. It tinges the flame of burning bodies carmine-red if moisture be present. It is soluble in 200 parts of water at the common temperature; boiling water dissolves it readily; and the solution on cooling shoots into regular crystals; these are thin quadrangular plates, sometimes square, oftener parallelograms. It has a great attraction for acids, but adheres to them with less force than barytes, and even with less than potash and soda. It combines with combustible bodies such as sulphur, phosphorus, &c. It is not poisonous to animals.

METHOD OF OBTAINING STRONTIA.

Strontia may be obtained from its native combinations by processes similar to those by which barytes is obtained (see page 223). It may also be procured by exposing the native carbonate of strontia to heat; care however must be taken not to have the fire too strong as the strontia in that case attacks the earthen crucible. The former methods are therefore preferable. In order to obtain it from sulphate of strontia, let a quantity of this mineral be reduced to powder; mix it with about one-sixth part of its weight of charcoal powder, and keep it for some hours red hot in a crucible. Then dissolve the mass in water, and pour nitric acid into the solution so long as a precipitate ensues. The solution is then to be filtered, evaporated till a strong pellicle appears, and suffered to crystallize. These crystals of nitrate of strontia may then be decomposed by exposing them to heat till all the nitric acid is driven off, which may be known by holding a piece of ignited charcoal over the fused nitrate, if the flame of the charcoal does not become enlarged the acid is dispelled. In order to obtain it crystallized it may be dissolved in boiling water, evaporated, and suffered to cool.

SECT. II.

EXPERIMENTAL PROOFS
OF
THE PROPERTIES OF STRONTIA

EXPERIMENT I.

Strontia tinges the flame of burning bodies carmine-red.

THIS may be shown by dissolving either strontia, or nitrate, or muriate of strontia in ardent spirit and setting fire to the solution, which will burn with a carmine-red flame.

REMARK...The experiment is best performed by moistening the strontia with ardent spirit in a silver spoon, setting fire to the mixture, and holding it while burning over the flame of a candle in order to cause a quick and rapid combustion.

REMARK...It is curious that moisture is absolutely necessary, for if the alkali be totally deprived of water by heat it does not produce this effect.

A beautiful red fire may also be produced by mixing one part of nitrate of strontia with two or three parts of charcoal powder and setting fire to the mixture with a red hot coal or a poker.

EXPERIMENT II.

Strontia combines with sulphur.

(Sulphuret of Strontia.)

If equal parts of strontia and sulphur are mingled together and exposed to a red heat, the substances unite and form a sulphuret of strontia of a yellowish brown colour.

When water is poured on sulphuret of strontia and the solution is evaporated, hydro-sulphuret of strontia is obtained in a crystalline state, and a hydrogenated sulphuret of strontia remains in the solution.

EXPERIMENT III.

Strontia combines with phosphorus.

(Phosphuret of Strontia.)

If six parts of strontia be mixed with one of phosphorus in an iron or earthen tube closed at one end, and the mixture be heated gradually to a dull red-heat, a combination takes place accompanied with a flash of light, as first noticed by Dr. Thompson. This phosphuret decomposes water, like the phosphuret of lime, discovered by Dr. Pearson,

EXPERIMENT IV.

Strontia combines with oxygenated muriatic acid; the decomposition of which, by sulphuric acid, is accompanied with a vivid emission of light and increase of temperature.

This curious fact was first noticed by Messrs. Davy and Clayfield.* In order to form oxygenated muriate of strontia, let a stream of oxygenated muriatic acid gas pass through a saturated heated solution of strontia in water, till it is neutralized, which may be known by the solution having acquired an orange colour. On pouring into this fluid a quantity of sulphuric acid, a great increase of temperature takes place, accompanied with a vivid emission of light. But no light is developed, if the acid be poured upon dry oxygenated muriate of strontia.

Q 3

* West Country Contrib. p. III.

LIME,

PART LXX.

SECT. I.

NATURAL HISTORY OF LIME.

THIS substance we have transferred from the class of earth, and placed it among the alcalies, for it possesses all the characteristic properties of these bodies in a striking manner, its sparing solubility in water only excepted.

Lime is found in great abundance in nature, though never pure, or in an uncombined state. It is always united to an acid, and very frequently to the carbonic acid, as in chalk, common lime-stone, marble, calcareous spar, &c. It is contained in the waters of the ocean; it is found in vegetables; and is the basis of the bones, shells, and other hard parts of animals. Its combination with sulphuric acid is known by the name of sulphate of lime (*gypsum*, or plaster of Paris). Combined with fluoric acid it constitutes fluuate of lime, or Derbyshire spar.

PROPERTIES OF LIME.

Lime is in solid masses, of a white colour, moderately hard, but easily reducible to powder. Its taste is bitter, urinous, and burning. It changes blue cabbage juice to a green. It is unalterable by the heat of our furnaces. It splits and falls into powder in the air, and loses its strong taste. It is augmented in weight and in size, by slowly absorbing water from the atmosphere. Its specific gravity is 2.3. It combines with phosphorus by heat. It unites to sulphur both in the dry and humid way. It absorbs sulphurated hydrogen gas. It unites with some of the metallic oxids. Its slaking by water is attended with heat, hissing, splitting, and swelling up, while the water is partly consolidated and partly converted into vapour; and the lime is reduced into a very voluminous dry powder, when it has been sprinkled with only a small quantity of water. It is soluble when well prepared in 300 parts of water. It unites to acids. It renders silix and alumine fusible, and more particularly these two earths together.

METHOD OF OBTAINING LIME.

Since the carbonic acid may be separated from the native carbonate of lime, this becomes a means of exhibiting the lime in a state of tolerable purity. For this purpose, introduce into a porcelain or earthen retort, or rather into a tube of green glass, well coated over with lute, and placed across a furnace, some powdered Carara marble or oyster-shell powder. Adapt to its lower extremity a bent tube of glass conveyed under a bell. If we then heat the tube, we obtain carbonic acid gas; and lime will be found remaining in the tube or retort.

REMARK...The burning of lime in the large way depends on the disengagement of the carbonic acid by heat: and, as lime is infusible in our furnaces, there would be no danger from too

violent a heat, if the native carbonate of lime were perfectly pure; but as this is seldom the case, an extreme degree of heat produces a commencement of vitrification in the mixt stone, and enables it to preserve its solidity, and it no longer retains the qualities of lime, for it is covered with a sort of crust which prevents the absorption of the water when it is attempted to be slaked. This is called over-burnt lime.

REMARK...It is probably owing to the first circumstance, that the lime prepared by Lord Stanhope, is so far superior to that met with in general.

In order to obtain lime in a state of great purity, the following method may be had recourse to.

Take Carara marble, or oyster-shells, reduce them to powder and dissolve the powder in pure acetous acid, precipitate the solution by carbonate of ammonia. Let the precipitate subside, wash it repeatedly in distilled water, let it dry and then expose it to a white heat for some hours,

RATIONALE...The acetous acid in this operation unites to the lime and forms acetite of lime, disengaging at the same time the carbonic acid, which flies off in the gaseous state: on adding to the acetite of lime carbonate of ammonia, acetite of ammonia, and an artificial carbonate of lime are formed, from the latter the carbonic acid is again expelled by exposure to heat, and the lime is left behind in a state of perfect purity.

SECT. II.

EXPERIMENTAL PROOFS
OF
THE PROPERTIES OF LIME.

EXPERIMENT I.

Lime condenses water rapidly, with an increase of temperature.

THIS may be shown by sprinkling a little water on some fresh burnt lime. The above mentioned phenomena will take place, and the lime will fall into powder. The degree of heat produced, if a large piece of lime be slaked, is even sufficient to set fire to a brimstone match, if the latter be introduced into the crack of it. For similar reasons vessels loaded with lime have been set on fire,

EXPERIMENT II.

Lime has a strong attraction for carbonic acid.

If we bring a jar filled with carbonic acid gas in contact with lime-water, and agitate the latter, a rapid diminution will ensue, and the lime-water become milky. It may also be shown by letting a current of carbonic acid gas pass into lime-water.

RATIONALE...The carbonic acid unites with the dissolved lime, and forms carbonate of lime, which on account of its insolubility is precipitated.

REMARK...Though lime saturated with carbonic acid forms an insoluble compound, yet when super-saturated with it, the product is re-dissolved, as will be evident from the following

EXPERIMENT III.

Lime sur-saturated with carbonic acid is soluble in water.

Add to a jar about one-fourth filled with lime-water, gradually, a very small quantity of water impregnated with carbonic acid, a milkiness will ensue, because the carbonic acid forms with the lime an insoluble compound. On adding more of the water, and shaking the jar as these additions are made, the milkiness at last disappears, and the whole precipitate becomes re-dissolved. Hence it is evident that lime, with a small quantity of carbonic acid, is insoluble; and, with a larger quantity, becomes again dissolved in water.

The carbonate of lime dissolved by an excess of acid is again separated, when this excess is driven off. Thus boiling, which expels the super-abundant acid, again precipitates the carbonate.

REMARK...It is thus that nature dissolves calcareous masses, which have been collected and deposited by the waters. When the waters by their exposure to the air, lose that quantity of carbonic acid which favoured the solution of the lime, deposits are formed, and hence the *stalactites* and incrustations found in caverns, springs, &c. and even the foliaceous calcareous *strata* of rocks, which without doubt have been held in solution.

When these waters suddenly lose the acid which was essential to the solution, there is an irregular precipitation; hence those tender calcareous cellular stones, and perhaps also the spongy *tuffs*; but if the evaporation of the carbonic acid takes place slowly, it produces crystallizations, such as *stalactites*, &c. All this there-

fore proves that carbonate of lime is not dissolved in water but by an excess of carbonic acid.

EXPERIMENT IV.

Lime absorbs carbonic acid and water from the atmosphere.

Lime-water remains unchanged in well closed vessels; but when exposed to the open air, it becomes covered with a thin pellicle, which, on becoming thicker, breaks and falls to the bottom, making room for another new crust, till at last all the lime is separated.

RATIONALE...The cause of the alterations which the lime-water undergoes when exposed to the air, originates from the carbonic acid of the atmosphere, being powerfully attracted by the lime dissolved in the water, which thus becomes converted into an insoluble carbonate of lime.

The same changes take place with lime itself when in contact with common air: it first attracts moisture and then carbonic acid; and being thereby gradually slaked, it swells up, splits, falls to pieces, and loses its sharp taste. Its weight is increased, and it becomes effervescent. It sensibly returns to the state of carbonate of lime. The greater the humidity of the air, the speedier these phenomena take place, and are the more striking. During this gradual slaking, heat is perceptible, by the absorbed water losing its caloric. It feels therefore warm, and a thermometer immersed in it, rises considerably above the temperature of the surrounding medium.

EXPERIMENT V.

Lime is soluble in water, it tinges blue vegetable colours green.

When more water is added to lime than is necessary to slake it, it becomes at last dissolved. About 300 parts of

water are required for one of lime. This solution is known by the name of *lime-water*. It has a pungent, alkaline taste; on adding it to an infusion of cabbage or violets, it changes their blue colour into green.

EXPERIMENT VI.

Lime unites to sulphur both in the dry and humid way.

This has been noticed already, vol. I. p. 130.

REMARK....Sulphuret of lime has lately been proposed for bleaching, by Professor Higgins of Dublin. The alternate immersion of the cloth in the oxygenated muriatic acid, and in a diluted solution of sulphuret of lime, is said to produce the same effect as the alternate application of the acid, and of a solution of potash or soda.

The combination of lime with phosphorus by heat, has been noticed, vol. I. p. 164.

EXPERIMENT VII

Lime fuses with silex and alumine at high temperatures.

Though lime is perfectly infusible as well as silex, yet if they are heated together they will become fused, provided the proportion of the former be considerably greater than that of the latter. Mixed with a third of its weight of alumine the mass may likewise be fused with facility.

A mixture of these three substances fuses much easier and more completely than lime with either of them singly; thus, one part of lime and one of alumine may bring into fusion two, and even two parts and a half of silex.

PREPARATION OF MORTAR AND CEMENTS.

Lime forms the principal part of the mortar or cement, used for connecting stones and bricks in buildings. It is generally made of lime, sand, and water. Its hardening is a species of crystallization, owing to a slow absorption of carbonic acid and water. No certain proportion of lime, silex, and water, for forming mortar, is adhered to in this country; we are informed however, that in the best mortar one part of lime and two of sand are generally mixt with so much water as is sufficient to give it a certain consistence. The lime, the sand, and the water require to be very much beaten together, in order to produce an intimate mixture and combination of them in their minutest particles, without which the mortar cannot possibly answer the intended purpose.

Water cement, or mortar, which has the property of hardening under water, may be prepared according to Guyton,* by mixing together four parts of blue clay, six of black oxid of manganese, and nine of carbonate of lime. This mixture is to be heated to a white heat, in order to decompose the carbonate of lime, it is then mixed with 60 parts of sand, and formed into mortar with a sufficient quantity of water.

Dr. Bryan Higgins has found that burnt bones improve the common mortar very much; and as the mortar prepared according to his direction is certainly the best that can be proposed, we shall shortly notice the composition of it. Take 56 parts of washed *coarse sand*, whose single grains do not exceed $\frac{1}{16}$ part of an inch in diameter, and 42 of *fine sand*. Mix and wet them with lime-water, add gradually 14 parts of slaked lime, beat it well together, and lastly, add a like quantity of powdered bone-ashes.

* Ann. de Chimie xxxvii, p. 259.

AMMONIA.

PART LXXI.

AMMONIA is very different from all the preceding alkalies by its great volatility; its irritating and pungent odour; its easy decomposition and recomposition, and consequently its well known nature. We are not capable of producing it pure in the solid form, but it always appears either combined with water, in a liquid state (liquid ammonia) or in the state of gas. It forms the prussic acid with ignited charcoal. It dissolves phosphorus and sulphur. It neither acts nor is acted upon by any terrene substance. It has greatly assisted the progress of modern chemistry in the knowledge of animal matters. Its nature and properties have been fully investigated under the article *ammoniacal gas*. (Vol. I. p. 309).

COMBINATION OF OXIGEN WITH COMBUSTIBLE BODIES.

THEORY
OF THE
DECOMPOSITION AND FORMATION
OF
WATER.

PART LXXII.

SECT. 1.

THE physical properties of water are well known ; many of them have been examined already. The object of the present part is, to show that water is a compound of two simple bodies, namely, oxigen and hidrogen, and that it may be decomposed into, and re-produced from them alternately.

DECOMPOSITION OF WATER BY CHEMICAL
AGENCIES.

Take a gun-barrel, the breech of which has been removed, and fill it with iron-wire, coiled up in a spiral form. To one end of the barrel adapt a small glass retort, partly filled with water ; and to the other, a bent glass tube, the open end of which terminates under the shelf of the pneumatic trough. Let the barrel

be placed in such a manner across a furnace, that the end to which the retort is luted be a little elevated. Then light a fire in the furnace, and, when the gun-barrel has become red-hot, apply a lamp under the retort containing the water. The steam of this fluid will thus pass through the red-hot iron barrel, and become decomposed. Its oxygen unites with the iron, and its hydrogen becomes liberated in the form of gas, and may be collected in the pneumatic trough.

The same experiment may be repeated, substituting a coated glass or earthen tube for a gun-barrel, and weighing the iron wire accurately before and after the experiment. The wire will be found to have gained weight, in proportion to the quantity of oxygen which formed the water. If this weight be added to that of the hydrogen gas it will make up exactly the weight of the water that has disappeared.

From experiments of this kind, conducted with the utmost accuracy, as well as from synthetic investigations, it appears that water is composed of 85 parts of oxygen, and 15 of hydrogen by weight very nearly. But as hydrogen gas is *at least* eleven times lighter than common air, the proportion of gases, by volume, required to form water, is about two of hydrogen to one of oxygen.

REMARK...Water may be decomposed in a similar apparatus, by distilling it over red-hot charcoal instead of iron wire, but in this case the oxygen of the water combines with part of the charcoal and forms carbonic acid gas, while its hydrogen unites to another portion of the charcoal, and produces carbonated hydrogen gas. (See vol. I. p. 245.)

DECOMPOSITION OF WATER BY ELECTRICITY AND GALVANISM.

Water has also been decomposed by the agency of electricity and galvanism. If uninterrupted electrical discharges be made to pass through a quantity of water, part of it is decomposed into

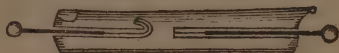
oxygen and hydrogen gases, and the mixture of these gases may be again inflamed by the electric spark so as to produce water.

This fact was first discovered by a society of Dutch chemists; and the principal circumstance in the experiment is, the transmission of electrical shocks, through a confined portion of water. The apparatus employed in this experiment by Messrs. Dieman and Van Troostwyk, is a glass tube, about one-eighth of an inch in diameter, and 12 inches long, one of the ends of which is sealed hermetically, a gold wire being inserted at this end, and projecting about an inch and half within the tube. About the distance of five-eighths of an inch from the extremity of this, another wire is to be fixed, which may extend to the open end of the tube. The tube is next to be filled with distilled water, and to be placed inverted in a vessel of the same. When thus disposed, electrical shocks are to be passed, between the two ends of the wire, through the water; and if these shocks be sufficiently strong, bubbles of air will be formed at each explosion, and will ascend, till the upper part of the wire is uncovered by the water. As soon as this is effected, the next shock that is passed sets fire to the air; and the water rises again in the tube, a very small quantity of gas remaining. Now as hydrogen and oxygen gases, in a state of admixture, are the only ones, that are capable of inflaming by the electric shock; and as there is nothing in the tube, besides water, that can afford them in this experiment, we may safely infer, that the evolved hydrogen and oxygen gases arise from decomposed water.

An improved apparatus, exhibiting the same experiment with less trouble to the operator, has been invented by Mr. Cuthbertson, and may be seen described and figured in Dr. Pearson's paper, in the *Phil. Trans.* for 1797, or in *Nicholson's Journal*, Vols. 1 and 2.

We are likewise indebted to Dr. Wollastone, for decomposing water in a more commodious manner than the former methods, which require a powerful electrical machine, and considerable labour. It is as follows:

Let two fine gold wires be fixed in separate small glass tubes by fusion; and let the ends of these tubes be ground away till the very section or extremity of each wire is laid bare: let the other end of each tube be furnished with a larger wire connected with a metallic ball, which wire communicates with the gold wire within. These two tubes are then fixed by fusion in a larger glass tube, provided with a conical drawn aperture, through which it can be filled with water, all but a small vacuity or bubble, and then sealed. The apparatus is then complete; and if a stream of electricity or galvanism, be passed through it, the water is decomposed. The apparatus will be more evident from the following sketch:



The method of decomposing water by galvanism was discovered by Messrs. Nicholson and Carlisle, in the year 1801. This discovery will, in point of importance, for ever remain among the first discoveries that have been made in philosophical chemistry. Nothing more is necessary for that purpose than to take a narrow glass tube 3 or 4 inches long; fit each end with a cork, penetrated by a piece of slender iron wire, and fill the tube with water. Let the ends of the two wires be distant from each other, about three-fourths of an inch; and let the one be made to communicate with the bottom of the galvanic pile, the other with the top. On making this communication, bubbles of air will form, and ascend to the top of the tube; the wire being rapidly oxidated. In this experiment, the water is decomposed; its oxygen unites with the iron, and its hydrogen appears in the state of gas.

If this experiment be made with the substitution, for iron, of some metal that is not oxidated by water, as gold for example, we obtain a mixture of hydrogen and oxygen gases, as in the experiment of Messrs. Dieman and Van Troostwyk.

SECT. II.

RE-COMPOSITION OF WATER.

IT is, however, not sufficient to decompose water into its constituent principles, oxygen and hydrogen, to produce complete conviction; we must re-compose it with the radicals which resulted from its decomposition: happily modern chemistry has enabled us to accomplish this.

It has been proved already, vol. I. p. 204, that oxygen and hydrogen gases, when fired in proper proportions, produce a quantity of water, equal in weight to the two gases employed; it is, therefore, obvious that, by thus exploding repeatedly portions of a mixture of these gases, a considerable quantity of water will at last be produced. This being established, it would be superfluous to dwell upon it further.

To perform the combustion of oxygen and hydrogen gases, for the production of water, conveniently, some particular kinds of apparatus have been invented. A simple contrivance, for showing the formation of it, we have noticed already, vol. I. p. 206: but the cheapest, most convenient, and most simple apparatus for that purpose has been invented by Mr. Cuthbertson, of which a description and drawing has been given in Nicholson's Journal, (4th edit.) vol. i. p. 235.

FORMATION OF ACIDS.

ACIDS.

PART LXXIII.

FORMATION OF ACIDS.

—

ACCORDING to the theory of Lavoisier all acids consist of a certain base united to oxygen, which is considered to be the cause of acidity. We are acquainted with the bases of the sulphuric, nitric, phosphoric, arsenic, &c. acids: we know that hydrogen, carbon, and oxygen, form the bases of the citric, malic, oxalic, acetic, gallic, and all the rest of the acids called *vegetable*; and that the same substances, in combination with nitrogen, constitute those called *animal* acids; such as prussic, &c. But we are totally unacquainted with the radicals of the muriatic, boracic, and fluoric acids, they must therefore be analogically considered as simple bodies in the present state of our knowledge.

We have divided the acids into three classes, viz.

1. Acids whose bases are unknown, or undecomposable acids.
2. Acids composed of two bases.
3. Acids composed of more than two bases.

The bases which become acid by the union of oxygen are capable of being united to it in various degrees. When the oxygenation is complete they are called *perfect acids*. But if they are not saturated with oxygen, they mostly appear in a state of less acidity. In the new nomenclature the termination IC is given to the complete oxygenation of these bodies, and the termination OUS when they present themselves in an imperfect state of combination with oxygen. Hence by the name of sulphuric acid, we mean sulphur completely saturated with oxygen; and by the name sulphureous acid, we understand sulphur not saturated with oxygen.

GENERAL PHYSICAL PROPERTIES OF ACIDS.

Acids are either in the solid, liquid, or gaseous state. They excite a peculiar sensation on the palate called *sour*. They change most of the blue vegetable colours red. Most of them unite to water in all proportions, and many have so strong an attraction for that fluid, as to be incapable of appearing in the solid form. They all combine with alcalies so strongly as to disengage them from many other substances. They mix with the earthy and metallic substances, and form combinations attended with numerous interesting phenomena; upon the due explanation of which a great part of the science of chemistry depends.

REMARK...It must be noticed however, that every acid does not possess all the properties here enumerated, but all possess a sufficient number to distinguish them from other substances; and this is the only purpose which artificial arrangement can possibly answer.

Class I..., ACIDS WHOSE BASES ARE UNKNOWN, OR
UNDECOMPOSABLE ACIDS.

MURIATIC ACID.

PART LXXIV.

MURIATIC acid exists in the gaseous state, and forms muriatic acid gas, which has been considered already, vol. I. p. 327. The basis of this acid is unknown.

PROPERTIES OF MURIATIC ACID,

Liquid muriatic acid, or water impregnated with muriatic acid gas, is a colourless, very odorous, and pungent fluid. It emits copious white fumes in contact with moist atmospheric air, these fumes are muriatic acid gas that escapes from it, and condenses again by combining with the humidity of the air. If a wide-mouthed bottle containing strong muriatic acid be opened, and the hand brought near its orifice, a sensible warmth is perceived, which arises from the combination of the acid gas with the water of the atmosphere. Liquid muriatic acid is unalterable by

any known combustible body. It disengages the carbonic, phosphoric, and sulphureous acids from all their combinations, but it is constantly expelled by the action of the sulphuric acid.

METHOD OF OBTAINING MURIATIC ACID.

Muriatic acid is best obtained by decomposing muriate of soda or common salt, by means of sulphuric acid, in the following manner:

Put into a tubulated retort, lodged in a sand-heat, or supported over a lamp, and connected with Pepys's distillatory vessel, or Woulf's bottles, every one containing a small quantity of distilled water; three parts of muriate of soda, and pour on it one of sulphuric acid very gradually, or rather let it be suffered to drop into the retort, by means of a funnel fastened to its tubulure, and whose inner opening may at pleasure be closed, wholly, or in part, by means of a ground-glass rod. Muriatic acid gas will be plentifully disengaged, which passes through the neck of the retort, and becomes absorbed by the water. When the water in the first bottle is fully saturated it absorbs no more and becomes cold, but the gas continues to pass into the next bottles, and heats the water they contain. The water thus impregnated with muriatic acid gas is called muriatic acid.

REMARK...If sulphuric acid diluted with an equal quantity, by weight, of water, be made use of in this process, the apparatus of Pepys or Woulf may be dispensed with, and a common receiver may be used with safety.

The salts formed by the combination of muriatic acid, with different bases, are called MURIATES.

PROPERTIES OF MURIATES.

These salts yield white vapours (muriatic acid gas) by the affusion of sulphuric acid, and yellowish-green vapours (oxygenated muriatic acid gas,) by nitric acid; both attended with considerable effervescence. They are decomposed by solution of silver, and are volatile at high temperatures without decomposition.

METHODS OF OBTAINING MURIATES.

Muriate of potash, soda, ammonia, barytes, strontia, lime, magnesia, &c. may be obtained by dissolving the carbonates of these substances in muriatic acid, to perfect saturation, evaporating the solution, and suffering it to crystallize. Muriate of iron may be produced by dissolving iron filings in muriatic acid to saturation, evaporating the solution and crystallizing it. Muriate of tin, zinc, arsenic, and nickel, may be obtained in a similar manner. Muriate of lead is best prepared by pouring muriatic acid into a solution of nitrate of lead, the muriate of lead precipitates instantly. Muriate of gold is obtained by dissolving gold in nitro-muriatic acid. Muriate of silver is formed by pouring muriatic acid into a solution of nitrate of silver. Muriate of copper is produced, according to Chenevix, by mixing 54.5 parts of black oxid of copper, and 50 parts of copper obtained by precipitating that metal from its solution, by a plate of iron, and putting this mixture with muriatic acid into a well stopped phial; the solution will then contain muriate of copper. Muriate of mercury has been noticed already. Muriate of bismuth is obtained by dissolving this metal in nitro-muriatic acid. Muriate of antimony is formed in a similar manner.

BORACIC ACID.

PART LXXV.

THE composition of this acid is also unknown. It exists united to soda in the salt called borax, or sur-saturated borate of soda. United to lime and magnesia, it forms the mineral called borate of lime.

PROPERTIES OF BORACIC ACID.

Boracic acid appears in brilliant, glittering, white, hexahedral scales, soft and unctuous to the touch. Its taste is bitterish, with a slight degree of acidity. It is soluble in alcohol which it causes to burn, when set on fire, with a green flame surrounded with a white one. It is of difficult solubility in cold water, but is easily dissolved in boiling water. When heated strongly it fuses into glass. If heated with water it is carried up by the aqueous vapour. It has no action on combustible bodies.

METHODS OF OBTAINING BORACIC ACID.

1. Dissolve any quantity of sur-saturated borate of soda in boiling water, and add to this solution sulphuric acid, by a little at a time, till the solution be rather more than saturated. Then

evaporate it slowly to one-third, and set it aside to cool; white scales will be deposited, which are boracic acid. After all the acid has been crystallized out of the solution, the salt must be re-dissolved, re-crystallized, and lastly, washed in distilled water, drained on filtering paper and then dried.

2. Boracic acid may likewise be obtained by sublimation, from two parts of sur-saturated borate of soda, one of sulphuric acid, and one of water.

The union of boracic acid with different bases, forms salts called BORATES.

PROPERTIES OF BORATES.

Borates are vitrifiable by heat, but they are not altered by combustible bodies. When concentrated solutions of them are boiled with sulphuric, nitric, or muriatic acid, they are decomposed, and deposit on cooling brilliant lamellated crystals of boracic acid.

METHODS OF OBTAINING BORATES.

Borate of soda, potash, or ammonia, may be formed by neutralizing these alcalies, with a concentrated solution of boracic acid.

Borate of lime is produced, by adding a strong solution of boracic acid to lime-water. Borate of magnesia is obtained by dissolving magnesia in boracic acid. Borate of alumine is formed by mingling a solution of borate of soda, and sulphate of alumine. Borate of silver may be formed, by pouring a solution of common borax into a solution of nitrate of silver. Borate of mercury is obtained in a like manner. Borate of copper is precipitated by mixing a solution of borax with sulphate of copper.

Borate of iron, borate of lead, borate of zinc, and borate of nickel, may be formed, by adding a solution of borax of commerce to solutions of these metals in nitric or muriatic acid. The new compounds precipitate.

FLUORIC ACID.

PART LXXVI.

THIS is another acid of which the composition is unknown. It exists in a gaseous state and forms fluoric acid gas, (see Vol. I. page 343.) United to water it constitutes liquid fluoric acid:

PROPERTIES OF FLUORIC ACID.

The distinguishing property of fluoric acid is, its power of dissolving and volatilizing silex. Its odour resembles muriatic acid. On being exposed to a moist atmospheric air, it emits white fumes. Its action upon all the inflammable substances is very feeble; it does not afford oxygen to them. It has no action upon most of the metals, but it dissolves many of their oxids.

METHOD OF OBTAINING FLUORIC ACID.

Put one part of finely pulverized fluuate of lime into a leaden or tin retort, and pour upon it two parts and a half of sulphuric acid. Lute the retort to a receiver of the same metal, contain-

ing one part of water, and apply a gentle heat. The fluoric acid gas disengaged will be absorbed by the water and form liquid fluoric acid, which must be kept in well closed leaden or tin bottles, or phials coated within with wax or varnish.

Fluoric acid united to different bases forms saline compounds called **FLUATES**.

PROPERTIES OF FLUATES.

Fluates may be decomposed by the affusion of dense sulphuric acid; but not by heat, or by combustible bodies. When strongly heated they become phosphorescent, emitting in the dark a lam-bent white light.

REMARK...The fluates of lime possess particularly this last property, those fluates which exhibit the most lively and varie-gated colours, constantly shine with a light inclining to the violet, with the single exception of the Siberian variety, which has been named *chlorophane*; and which, though of a violet colour, gives a phosphorescence of a beautiful emerald green. It emits this light even under water, under oil, or *in vacuo*. When heated too strongly it ceases to shine altogether.

METHODS OF OBTAINING FLUATES.

Fluate of potash, soda, ammonia, or magnesia, may be prepared by saturating their carbonates with fluoric acid.

Fluate of barytes is precipitated by adding fluoric acid to the nitrate, or muriate of barytes. Fluate of strontia is prepared in a similar manner.

Fluate of silex is produced by suffering fluoric acid to be in contact with silex. Fluate of iron is obtained by dissolving the red oxid of iron in fluoric acid. Fluate of mercury, fluate of tin, and fluate of silver are precipitated, by dropping fluate of potash into the nitric or muriatic solutions of these metals.

Class II....ACIDS COMPOSED OF TWO BASES.

OXIGENATED MURIATIC ACID.

PART LXXVII.

THE name of oxigenated muriatic acid is given to the compound formed by the muriatic acid with oxygen. By this combination, however, the acid properties of the muriatic acid are not increased, as is the case with the other acids, but on the contrary, diminished.

Oxigenated muriatic acid exists in the state of gas, and as such has been considered, vol. I. p. 333. When absorbed by water it forms liquid oxigenated muriatic acid.

PROPERTIES OF OXIGENATED MURIATIC ACID.

Oxigenated muriatic acid, in a liquid form, is of a greenish-yellow colour. It has a styptic bitter taste, and a very suffocating odour. Instead of reddening blue vegetable colours, it has the remarkable property of rendering them white. In high temperatures, when light is excluded, phosphorus remains unaltered

270 METHOD OF OBTAINING OXIGENATED MURIATIC ACID.

in liquid oxygenated muriatic acid; but if light be admitted, the colour of the acid gradually disappears, and the phosphorus is converted into phosphoric acid. It thickens oils and animal fats, and renders them less disposed to combine with alcalies. Its action upon metals presents phenomena extremely curious and important; the oxygen of the acid unites with the metal, and the produced oxid is afterwards dissolved by the de-oxidated acid.

For the rest of its properties, see oxygenated muriatic acid gas.

METHOD OF OBTAINING OXIGENATED MURIATIC ACID.

Put into a tubulated retort, supported over a lamp, one part of black oxid of manganese reduced to a gross powder, and pour over it three parts of concentrated muriatic acid, recline the retort in such a manner that the fluid which rises up into its neck, may easily run back again into the body, and apply a receiver with a little distilled water in it; the receiver must be luted to the retort by a fillet of paper. When the effervescence, which instantly takes place on the affusion of the acid ceases, apply a gentle heat. Oxygenated muriatic acid gas will be evolved, and the receiver become filled with yellow vapours, which are absorbed by the water. When the water has acquired a yellowish-green colour, the receiver may be removed, and another one applied till no more gas is extricated. The process may be more elegantly conducted by joining the apparatus of Burkitt or Pepys, to the distillatory vessel. The common muriatic acid which may arise is condensed in the first bottle, and the oxygenated muriatic acid gas unites to the water in the second, third, &c.

The union of oxygenated muriatic acid with different bases, forms salts known by the name of OXIGENATED MURIATES.

PROPERTIES OF OXIGENATED MURIATES.

These salts are distinguished from all the rest by yielding oxygen gas when heated, and thus becoming converted into muriates. They detonate very violently by friction and percussion with the easily inflammable bodies.

PREPARATION OF OXIGENATED MURIATES.

Preparation of oxigenated muriate of potash.

To prepare this salt, the usual materials for preparing oxigenated muriatic acid gas, (vol. I. p. 304,) are put into a retort connected with Pepys's or Burkitt's apparatus. A solution of potash is put into the receivers, leaving the first empty, and thus saturating the potash by passing a current of oxigenated muriatic acid gas through it. When the saturation is nearly complete the oxigenated muriate of potash separates in crystals.

When three parts of oxigenated muriate of potash and one of sulphur are triturated in a mortar, the mixture detonates violently, the same effect is produced when the mixture is struck with a hammer on an anvil. Phosphorus detonates with oxigenated muriate of potash with a prodigious force. Similar effects are produced with other inflammable substances, or with metallic bodies. Some of them may be inflamed by the affusion of sulphuric or nitric acid.

REMARK...It is singular that the oxigenated muriatic acid gas does not combine directly with the alkali, but suffers a partial decomposition; one part of it becomes actually converted into muriatic acid, and consequently forms muriate of potash; the other part receives the oxygen with which the former parted, and combines with another portion of potash, forming a salt in which the acid exists, with a larger proportion of oxygen than in its usual state of oxigenated acid. This salt, therefore, is properly speaking, not an oxigenated muriate, but a *hyper-oxigenated muriate*

of *potash*. These singular combinations seem to be owing, to the stronger attraction of the alkali to muriatic, than to oxygenated muriatic acid, assisted by the attraction which the latter has for a still larger portion of oxygen.

Oxygenated muriate of soda or lime, may be obtained in a similar manner. The method of producing oxygenated muriate of strontia has been noticed before, page 245.

Oxygenated muriate of copper is obtained by dissolving the oxid of copper in cold muriatic acid, or dissolving copper by heat in muriatic acid. Oxygenated muriate of iron is produced by dissolving the red oxid of iron in muriatic acid. Oxygenated muriate of tin is produced by passing oxygenated muriatic acid gas through a solution of muriate of tin. Oxygenated muriate of lead is obtained in a similar manner.

NITRO-MURIATIC ACID.

Nitro-muriatic acid is a mixt or compound acid analogous to the former. It was formerly known by the name of *aqua regia*. It is produced by adding muriatic acid to the nitric: one part of the former is generally added to two of the latter.

During this combination an effervescence takes place, heat is liberated, and oxygenated muriatic acid gas becomes evolved; this action may be assisted and prolonged by the application of heat. The mixture assumes a yellow colour. It has the property of dissolving gold and platina.

RATIONALE...The muriatic acid attracts part of the oxygen of the nitric acid, thus converted partly into nitrous acid, and partly into nitrous gas, whilst the simple muriatic acid becomes converted, by this addition of oxygen, into oxygenated muriatic acid, or nitro-muriatic acid.

REMARK...The same acid combination may be produced by mingling together oxygenated muriatic acid and nitrous gas.

From what has been said before, it is obvious that the salts formerly called NITRO-MURIATES cannot exist.

SULPHURIC ACID.

PART LXXVIII.

SULPHUR is capable of combining with two different proportions of oxygen; with the smaller quantity it forms sulphureous acid; with the larger, sulphuric acid. The last of these is the subject of our first enquiry.

PROPERTIES OF SULPHURIC ACID.

Sulphuric acid is in the form of a dense liquid, slightly viscid; it runs in *striae*, like oil, when poured from one vessel into another. Its specific gravity is in general 1.85, at least it is prepared of that strength in some of our principal manufactures.* In its pure state it is colourless and void of odour. It is of considerable fixity in the fire, and requires a strong heat for ebullition. On being mingled with water heat is instantaneously evolved. (vol. I. p. 51.) It is not altered by oxygen, nitrogen, or

VOL. II.

S

* By Mr. Sandman in Queen Street, and Mr. Dobbs, Maid Lane, Borough.

hydrogen gases. It combines with nitrous acid, and forms a compound which dissolves silver, but scarcely any other metal. (Page 158.) It is decomposable by a number of inflammable substances which attract its oxygen. If brought in contact with any vegetable or animal matter, it is partially decomposed, and a quantity of carbon is disengaged which gives the acid a brown or black colour. It oxidates and dissolves a number of the metals, either affording to them part of its oxygen, or enabling the metal to decompose the water which is present. It attracts water from the atmosphere.

METHODS OF OBTAINING SULPHURIC ACID.

The processes employed for obtaining sulphuric acid may be reduced to two, namely; to unite sulphur to oxygen, or to separate the acid from its combinations met with in nature.

The first method is made use of in this country; for which purpose peculiar buildings or apartments, with their insides lined with lead are constructed. In these apartments sulphur is burnt, in order to absorb oxygen from the air during its combustion. But as the sulphur would not burn or become fully oxidated in a confined quantity of air, $\frac{1}{8}$ to $\frac{1}{12}$ of nitrate of potash is previously mixed with it in order to make it burn with vivacity, or to gain oxygen from the nitric acid. The sulphuric acid which is formed is absorbed by a *stratum* of water at the bottom of the chamber. The water, after being sufficiently impregnated, is exposed to heat in large glass retorts, so as to deprive the acid of the superfluous water, the sulphureous acid, and nitrous gas, with which it is mixed.

RATIONALE...The theory of this process has been noticed already, vol. I. p. 145.

REMARK...The sulphuric acid obtained in this manner is not perfectly pure, but always contains small quantities of sulphate of lead and sulphate of potash; from which it may be freed by re-distillation.

Sulphuric acid united to alcalies, earths, &c. forms saline combinations called **SULPHATES**.

PROPERTIES OF SULPHATES.

All the sulphates are insoluble in alcohol. Their solutions are decomposed by a solution of barytes. They become converted into sulphurets by ignited charcoal at high temperatures, but they are undecomposable by mere heat.

METHODS OF OBTAINING SULPHATES.

Sulphate of potash, soda, or ammonia may be obtained by saturating these alcalies with sulphuric acid, evaporating the solution and crystallizing it. Sulphate of magnesia, and sulphate of alumine may be produced in a similar manner. Sulphate of lead may be obtained by pouring sulphuric acid into a solution of acetite of lead, the sulphate of lead precipitates. Sulphate of zinc is produced by dissolving this metal in diluted sulphuric acid and subsequent evaporation and crystallization. Sulphate of nickel, sulphate of bismuth, and sulphate of cobalt, are produced by dissolving the metals, by the assistance of heat, in sulphuric acid, and proceeding as before.

Sulphate of iron is obtained by dissolving iron filings in diluted sulphuric acid, evaporating the solution and subsequent crystallization. This salt, if exposed to the air, soon becomes covered with a yellowish crust, because it absorbs more oxygen and becomes partially converted into an oxi-sulphate of iron, which is of a red colour, uncrystallizable, and soluble in alcohol; it may be deprived of its excess of oxygen by passing a current of sulphurated hydrogen gas through it.

SULPHUREOUS ACID.

PART LXXIX.

THIS constitutes the imperfect degree of oxigenation of sulphur; that is to say, the sulphur is not fully saturated with oxigen. Sulphureous acid naturally exists in the gaseous state.

PROPERTIES OF SULPHUREOUS ACID.

The acid properties of sulphureous acid are not considerable. It does not redden blue vegetable colours, but on the contrary renders them white. It exerts little action on metallic substances, and has a feeble attraction for the alcalies and earths. It is exceedingly volatile, and assumes the state of gas, if moisture be excluded.

For a fuller account of this acid we refer our reader back to sulphureous acid gas, vol. I, p. 317.

METHODS OF OBTAINING SULPHUREOUS ACID.

1. To prepare sulphureous acid, take one part of mercury and four of concentrated sulphuric acid, put them into a retort, furnished with a receiver, and connected with Burkitt's or Pepys's

apparatus. The sulphureous acid gas which is disengaged is absorbed by the water in the vessel, and constitutes sulphureous acid.

2. Sulphureous acid is likewise formed during the slow combustion of sulphur, as directed, vol. I. p. 144.

The salts formed by the combination of sulphureous acid with different bases, are called **SULPHITES**.

PROPERTIES OF SULPHITES.

All the salts of this class yield sulphur, and are converted into *sulphates* by heat. The nitric and oxygenated muriatic acids also convert them into *sulphates*.

METHODS OF OBTAINING SULPHITES.

Sulphite of potash, soda, ammonia, barytes or lime may be obtained by receiving a stream of sulphureous acid gas into a concentrated solution of the base employed, and then evaporating it for crystallization. Sulphite of magnesia is produced by saturating carbonate of magnesia with sulphureous acid. Sulphite of ammonia and magnesia is obtained by mingling together solutions of sulphite of magnesia, and sulphite of ammonia. Sulphite of lead may be produced by dissolving carbonate of lead in sulphureous acid. Sulphite of bismuth, and sulphite of antimony are precipitated by pouring sulphureous acid into muriate of antimony, or bismuth. Sulphite of iron may be formed in a direct manner.

PHOSPHORIC ACID.

PART LXXX.

WHEN phosphorus is united to oxygen the result is an acid, which varies according to the quantity of oxygen which joins to the phosphorus. Phosphorus saturated with oxygen forms phosphoric acid.

PROPERTIES OF PHOSPHORIC ACID.

Phosphoric acid is capable of existing in a dry and crystallized state. When solid, and placed in contact with a small quantity of water, it dissolves, and affords a ponderous transparent fluid, void of odour. When exposed to heat it is rendered viscous; it gradually becomes more consistent, and loses its transparency. Lastly, when urged by a violent heat, in a silver or platina crucible, it melts into a transparent glass, which again attracts moisture when exposed to the air, and becomes converted into liquid phosphoric acid. When melted in an earthen crucible the acid acts upon it and fuses into a glass, which is *not soluble in water*, and exhibits *no signs of acidity*. It has a strong attraction for all the alcalies, and likewise for the earths. It acts only on a small number of metallic substances.

METHODS OF OBTAINING PHOSPHORIC ACID.

1. To obtain phosphoric acid the bones of adult animals are generally made use of. For that purpose, dilute in a spacious

glass jar, one pound of sulphuric acid with six or eight pounds of water; then add gradually, and with constant stirring, one pound and a half of finely pulverized bones burnt to whiteness. An effervescence will take place. When this has ceased leave the whole on a gentle sand-bath for a few hours, taking care to stir it frequently, and to supply the loss of water which happens by evaporation. After it has been suffered to remain undisturbed, strain the whole through a cloth, and wash the residual matter repeatedly in water till it passes tasteless. The fluid thus obtained contains the phosphoric acid, contaminated with lime, and may be evaporated in a Wedgwood's, or glass bason, to any wished-for consistence.

REMARK...The phosphoric acid obtained in this manner is not pure, but contains a considerable quantity of lime. To obtain it in its pure state, carbonate of ammonia must be added until no more precipitate falls down, the precipitate is carbonate of lime, which must be separated by filtration; the fluid being then evaporated to dryness leaves phosphate of ammonia. This is exposed to heat in a china cup, till all the ammonia is disengaged, which may be known by the mass frothing no longer, but flowing quietly. On cooling, it congeals into a transparent vitreous substance, called glacial acid of phosphorus, which attracts moisture, and is soluble in water.

2. Phosphoric acid may likewise be obtained by the rapid or complete oxygenation of phosphorus, by burning it in oxygen gas, as mentioned before, vol. I. p. 188.

3. *Scheele* has contrived a method of converting phosphorus into phosphoric acid without combustion; namely, by the action of nitric acid.

In this operation a tubulated glass retort must be half filled with pure nitric acid, and a gentle heat applied. A small piece of phosphorus being then introduced through the tubulure will be dissolved with a rapid effervescence, and a quantity of red vapour will be disengaged. The addition of phosphorus in small pieces must be continued until the last piece added remains un-

dissolved in the boiling acid. The piece of phosphorus which produces no further change in the acid is then to be taken out, and the fire raised to drive over the remainder of the nitric acid. The phosphoric acid will then be found in the retort, partly in a concrete and partly in a liquid form.

RATIONALE...In this process a decomposition of the nitric acid takes place, the phosphorus at the temperature of the heated acid attracts its oxygen, and becomes converted into phosphoric acid; and the nitrogen becomes free and flies off in the gaseous state.

The combination of phosphoric acid with different bases, forms the salts called PHOSPHATES.

PROPERTIES OF PHOSPHATES.

These salts are fusible, before the blow-pipe, into a globule of glass. They are soluble in nitric acid, from which they are precipitated by lime-water. Most of them do not afford phosphorus when heated with charcoal.

METHODS OF OBTAINING PHOSPHATES.

The principal of these salts are the phosphates of soda, potash, ammonia, magnesia, barytes, and strontia. They are prepared by saturating the carbonates of these bodies with phosphoric acid, and proceeding in the manner directed for the preparation of sulphates. Phosphate of mercury is precipitated by mingling a solution of phosphate of soda, and nitrate of mercury. Phosphate of copper is formed in a similar manner, by letting fall a solution of phosphate of soda into a solution of nitrate of copper. Phosphate of iron is precipitated by mixing a solution of phosphate of potash with a solution of sulphate of iron. Phosphate of lead and phosphate of bismuth, are produced by dropping a solution of phosphate of soda into nitrate of lead or bismuth. Phosphate of tin or zinc is formed in a similar manner.

PHOSPHOROUS ACID.

PART LXXXI.

WHEN phosphorus is burnt slowly, and does not become completely saturated with oxygen, it forms an acid differing from the former, called phosphorous acid.

PROPERTIES OF PHOSPHOROUS ACID.

Phosphorous acid is liquid, transparent, and of considerable density. It has an unpleasant taste, and emits an alliaceous and disagreeable odour when rubbed, and especially if warmed. When heated more strongly, part of it is volatilized in the form of a white vapour which is very acute, penetrating, and luminous in the dark. It is much more volatile than phosphoric acid; and always contains a greater or less quantity of phosphorus.

METHODS OF OBTAINING PHOSPHOROUS ACID.

To obtain phosphorous acid we merely expose phosphorus to the air: the phosphorus by this means undergoes a slow combustion, and is gradually changed into phosphorous acid. To

effect this in a commodious manner, sticks or pieces of phosphorus may be placed on the inclined side of a glass funnel, whose neck is received in a phial containing a little distilled water, and its base covered, but not closely. A tube, or small pieces of glass are put into the neck of the funnel, in order to prevent the phosphorus from falling through into the phial, and to give a free passage to the air of the vessel displaced by the phosphorous acid. Care must be taken that the sticks of phosphorus touch each other as little as possible

Phosphorous acid with alkaline, terrene, or metallic bases, forms salts called PHOSPHITES.

PROPERTIES OF PHOSPHITES.

Phosphites detonate with oxigenated muriate of potash. When heated in the open air they yield a phosphorescent flame.

METHODS OF OBTAINING PHOSPHITES.

Phosphite of potash, soda, ammonia, or lime, may be prepared by dissolving the respective carbonates in phosphorous acid, and proceeding as directed before. Phosphite of barytes and strontia are produced by mingling together phosphorous acid, and barytic or strontia water. Phosphite of magnesia is obtained by mingling phosphite of potash or soda with sulphate of magnesia. Phosphite of alumine may be produced by saturating phosphorous acid with alumine.

CARBONIC ACID.

PART LXXXII.

CARBONIC acid exists, in the gaseous state, at common temperatures, and at any pressure of the atmosphere which we know of. It is therefore a permanent, elastic, aeriform fluid, and has been considered as such under the article carbonic acid gas, vol. I. p. 234, to which we refer the reader for a fuller account of it.

The combination of carbonic acid with different bases, constitutes **CARBONATES**.

PROPERTIES OF CARBONATES.

Carbonates produce a rapid effervescence when mixed with sulphuric, nitric, muriatic, &c. acids. Most of them are decomposable by heat. Some of them are insoluble in water, but become soluble by an excess of carbonic acid. Several of the alkaline carbonates change vegetable blues to green, and have an alkaline taste.

METHODS OF OBTAINING CARBONATES.

Carbonate of potash is prepared by passing a current of carbonic acid gas, for a considerable time, through a solution of potash; or, by distilling potash with carbonate of ammonia. Carbonate of soda may be prepared in a similar manner. Carbonate of magnesia is prepared by adding carbonate of potash to a solution of sulphate of magnesia as long as any precipitate ensues. Carbonate of ammonia is obtained by distilling two parts of dry carbonate of lime with one of nitrate of ammonia. Carbonate of silver is precipitated by pouring carbonate of potash, or soda, into a solution of nitrate of silver. Carbonate of mercury is produced in a similar manner by mingling the solution of an alkaline carbonate with nitrate of mercury. Carbonate of copper is precipitated by decomposing a solution of nitrate of copper, by adding to it a carbonated alkali. Carbonate of iron is precipitated by dropping into a solution of sulphate of iron, a solution of carbonate of soda or potash. Carbonate of tin, lead, nickel, or zinc, may be produced by decomposing the solutions of these metals by the same alkalies.

NITRIC ACID.

PART LXXXIII.

PROPERTIES OF NITRIC ACID.

NITRIC acid is liquid, colourless, and transparent, possessing in a very eminent degree all the properties of acids. It tinges the skin yellow, which does not disappear till the *epidermis* wears off. It has a strong affinity for water, and has never yet been found in nature except in combination. It produces heat when added to water. When concentrated it exhales white acrid fumes on being exposed to the air, which are nitric acid in a gaseous state. When poured on oils, charcoal, &c. it sets them on fire. (See vol. I. p. 19.) It causes the sulphureous and phosphorous acids to pass to the state of sulphuric and phosphoric acids, by yielding to them part of its oxygen. It is capable of oxidating all the metals except gold, platina, titanium, and tantalite.

METHODS OF OBTAINING NITRIC ACID.

Nitric acid cannot be produced in any considerable quantity, by the direct combination of its principles, without a great deal of labour; though that it may be so formed for the sake of experiment has been shown, vol. I. p. 211.

The following method of obtaining nitric acid is made use of by chemists.

Take two parts of dry nitrate of potash in coarse powder, put it into a tubulated glass retort, of which it occupies no more than one-third, or one-fourth, and to which a large receiver has been luted containing a little water; then pour on it, in small quantities, at a time, one part of concentrated sulphuric acid. As soon as the last quantity of the acid is introduced into the retort apply a very gentle heat, and distil slowly till no more drops issue from the neck of the retort. The acid collected in the receiver is fuming and of a reddish or yellow colour: on being brought into contact with atmospheric air, it sends forth reddish-yellow fumes, which likewise always fill the empty space of the receiver or bottle. In order to deprive it of these fumes, the acid must be re-distilled, or at least heated for some time in a glass retort, with a very gentle heat; the fuming part will rise first, and the remainder will be deprived of all its colour and fuming property.

REMARK...The property of emitting reddish-yellow fumes does not belong to the pure nitric acid, for this is one of the characteristics of another kind of acid, called nitrous acid, which we shall presently consider. The fumes which are evolved are nitrous gas, originating from a partial decomposition of a certain part of the acid during its disengagement from the nitrate of potash; hence it is soiled with nitrous gas. On exposing the acid to heat, or re-distilling it, this nitrous gas becomes disengaged, and pale nitric acid is obtained.

The combinations of nitric acid with different bases, are called NITRATES.

PROPERTIES OF NITRATES.

These salts detonate with, or inflame charcoal, and other easily inflammable bodies, at a red heat. They afford oxygen and

nitrogen gases at high temperatures, and yield yellowish vapours, (nitrous acid) by the affusion of sulphuric acid, especially if heat be applied.

REMARK...It is upon the property of the detonation of nitrates with inflammable substances that the composition of gun-powder is founded, which consists of 5 parts of nitrate of potash, 1 of charcoal, and 1 of sulphur.

Powder of fusion, as it is called, consists of 3 parts of nitrate of potash, one of sulphur, and one of fine dry saw-dust. If a small quantity of this powder is put into a walnut-shell, with a thin piece of copper coin rolled up, and the money then be covered up with the powder, it may be melted by setting fire to the mixture, which will burn vividly without injuring the shell.

A mixture of one part of nitrate of potash and two of acidulous tartrite of potash, (or common flour) after being detonated, forms what is denominated *black flux*.

White flux is produced by detonating equal parts of nitrate of potash and acidulous tartrite of potash, or flour, in a similar manner.

METHODS OF OBTAINING NITRATES.

Nitrate of potash, soda, ammonia, barytes, or strontia may be prepared by neutralizing the carbonates of these alcalies with nitric acid, evaporating the solution and suffering it to crystallize. Nitrate of magnesia is produced in a similar manner. Nitrate of silver is obtained by dissolving silver in nitric acid, evaporating the solution until a pellicle appears, and then setting it aside to crystallize. Nitrate of mercury, copper, nickel, lime, or cobalt may be produced in a similar manner. Nitrate of iron is obtained by dissolving iron in nitric acid. On evaporating the solution a red precipitate appears consisting of iron, oxidated to its *maximum*.

NITROUS ACID.

PART LXXXIV.

IT was until very lately a generally received notion, that the proportion of oxygen in nitrous acid was less than that existing in the nitric acid, and that it was therefore less oxygenated; but this is certainly not the case. Mr. Thompson's* remarks concerning nitrous acid, and Davy's† observations are sufficient to prove the contrary; with these gentlemen, we consider nitrous acid as nothing more than nitric acid holding in solution, that is, loosely combined with it, a greater or less quantity of nitrous gas, and being therefore more or less coloured and fuming, according to the quantity of gas it contains.

PROPERTIES OF NITROUS ACID.

Nitrous acid exists in the state of gas, in the form of a red vapour, slightly coercible. When combined with water it is of a yellow or orange colour. It emits copious orange-coloured, or red fumes. It is more decomposable than nitric acid and inflames combustible bodies more readily. It has a strong attraction for water, and their combination is attended with an increase of temperature. Different portions of water convert its colour to a deep blue, green, yellow, &c. while the vapours still continue of their original yellowish-red colour.

* Davy's Researches, &c. p. 31.

† Ibid, p. 32.

METHODS OF OBTAINING NITROUS ACID.

The common mode of obtaining nitrous acid is to decompose nitrate of potash by means of sulphuric acid with the assistance of heat. The nitric acid, as has been stated already, suffers a partial decomposition during the process, and hence it is the nitrous acid which is obtained in the first process of distillation.

It seems to be true that nitrous acid of a much darker orange red colour is obtained by decomposing nitrate of potash by means of sulphate of iron, than when the same salt is decomposed by sulphuric acid. The following is the process made use of by our manufacturers.

Take a quantity of sulphate of iron, deprived of its water of crystallization by heat, and mix it with an equal weight of dry nitrate of potash; put the mixture into a glass retort, to which a very spacious receiver has been luted, containing a little water, and begin the distillation with a very slow fire. As soon as the red vapours cease to come over let the fire be slackened, and when the vessels are cooled the receiver may be cautiously withdrawn, and its contents quickly transferred through a glass funnel into a bottle, furnished with a ground stopper.

REMARK...The salts which, according to the principles of the new nomenclature, are called *nitrites*, cannot be formed by a direct combination. For the *nitric* acid only enters into combination with the body to which it is presented, and the *nitrous* gas becomes disengaged. They may however be obtained by partially decomposing nitrate of potash, or other nitrates, by a moderate heat. These salts however, are more properly to be considered as compounds of nitric acid and the substances with which it is united, to which a portion of nitrous gas slightly adheres; and this gas can be expelled by the addition of any weak acid. They have been very little examined.

ARSENIC ACID.

PART LXXXV.

ARSENIC acid is always a product of art. It is arsenic fully oxygenated.

PROPERTIES OF ARSENIC ACID.

Arsenic acid is capable of existing in the solid state. It appears in the form of a white pulverulent matter. It attracts humidity from the air. It is soluble in water. This solution possesses a considerable acid taste. It may be evaporated to dryness and even converted into glass. It is decomposable by all combustible bodies and by many oxids. It is soluble in some acids but without change or intimate combination.

METHOD OF OBTAINING ARSENIC ACID.

Take two ounces of arsenious acid in powder, put it into a tubulated retort, pour on it six or seven ounces of muriatic acid, and apply the heat of a lamp until the arsenious acid is dissolved. Then add three or four ounces of nitric acid and heat it again gradually. An intestine motion now takes place, and much red vapour or nitrous gas is extricated. As soon as in the progress of the operation, the red vapours have ceased, an ounce of finely powdered arsenious acid is to be again added, and the solution effected as before, by a gentle ebullition; to this two

ounces of nitric acid must be added, which will produce a second effervescence and discharge of red vapours, the distillation must now be continued to dryness, and the fire must be urged towards the end, to such a degree, as to make the residual mass thoroughly red-hot. This mass is arsenic acid, which may either be preserved in that form or be dissolved in boiling distilled water.

REMARK...All the preparations of arsenic are deadly poison. The hidro-sulphurets are the best antidotes. A diluted solution of hidro-sulphuret of potash, soda, or lime, is therefore administered with success, to persons who have been poisoned by arsenic. For the same reason sulphureous mineral waters may be given in such cases; oil, milk, butter, &c. which are too often resorted to, should never be employed, if a sulphuret or hidro-sulphuret can possibly be procured.

Arsenic acid united to different bases forms saline compounds, called ARSENIATES.

PROPERTIES OF ARSENIATES.

These salts are distinguished by being precipitated from their solutions, in the form of a yellow powder, by water holding sulphurated hydrogen gas in solution, or by hidro-sulphuret of ammonia. When heated in contact with charcoal powder they are decomposed and arsenic sublimes.

METHOD OF OBTAINING ARSENIATES.

Arseniate of potash, soda, ammonia, or magnesia, may be obtained by saturating their carbonates with arsenic acid. Arseniate of lime is produced by pouring arsenic acid into lime-water. Arseniate of silver precipitates, if arsenic acid is dropt into a solution of nitrate of silver. In a like manner arseniate of mercury is produced.

ARSENIOUS ACID.

PART LXXXVI.

THE earliest chemists were embarrassed in the determination of the nature of the poisonous white substance known in commerce by the name of *white arsenic*. Subsequent experiments have shown that this substance is metallic arsenic oxygenated in the first degree. The name of *arsenious acid* is therefore given to it. It is sometimes found in nature in sublimed crystals, in volcanoes; and in masses, or in stalactites among the ores of arsenic, cobalt, bismuth, and nickel.

PROPERTIES OF ARSENIOUS ACID.

Arsenious acid possesses a weak sub-acid taste, which slowly manifests itself. Though of but a feeble acidity it sensibly reddens the tincture of cabbage and litmus. If placed on burning coals or on a red-hot iron, it is volatilized in the form of a white vapour, which has a strong smell of garlic. It is slightly soluble in water. With phosphoric and boracic acids it fuses into glass. It decomposes the nitrates and the super-oxygenated muriate of potash. It unites with many of the earths and alcalies, and forms saline compounds.

METHODS OF OBTAINING ARSENIOUS ACID.

1. Pulverize arsenic, and put as much of it into a Florence flask as will fill it about one half or less. Introduce a little tow

or cotton into the neck of the flask, and apply the heat of a lamp. A dense white smoke will be formed, and become precipitated on the internal sides of the flask. If the process be kept up till all the arsenic be oxidated, (which may be known by introducing a wire into the flask for a moment, which will become covered with a white crust, if the sublimation be not completed,) and the heat be then gradually augmented, the sublimed arsenious acid undergoes a sort of fusion, and an opaque white mass similar to that met with in commerce is obtained.

2. The arsenious acid of the shops (or white arsenic) is chiefly obtained from arsenical ores of cobalt. These ores are thrown into a furnace resembling a baker's oven, with a long flue or chimney, either horizontal or winding, into which the fumes pass, and are condensed into a greyish or blackish powder. This is refined by a second sublimation in close vessels, with a little alkali to arrest the impurities. As the heat is considerable it melts the sublimed arsenious acid into those opaque crystalline masses which are known in commerce, by the name of white arsenic.

Arsenious acid united with different bases forms salts called ARSENITES.

PROPERTIES OF ARSENITES.

These combinations were formerly known by the fanciful appellation of *livers of arsenic*. They do not crystallize, but all of them appear in the form of a thick viscid yellow-coloured liquid, of a nauseous odour. They are decomposable by heat, and by the affusion of all the acids. They have been but very superficially examined, and are by no means sufficiently known to admit of a detailed description. They may be formed by dissolving arsenious acid in alkaline solutions.

TUNGSTIC ACID.

PART LXXXVII.

THIS acid does not exist in nature in an uncombined state, but always united to lime, (*tungstate of lime*,) or with iron and manganese, (*wolfram*.)

PROPERTIES OF TUNGSTIC ACID.

Tungstic acid appears in a pulverulent form, harsh to the touch. It is tasteless and insoluble in water. It is incapable of turning blue vegetable colours red, until it has been first rendered soluble by ammonia. It is of a yellow colour, which becomes blue on being exposed to the light, (vol. I. p. 125.) When put into muriatic acid with tin, zinc, or iron, it yields to them its oxygen, and hence the liquor becomes blue. It becomes also blue when boiled with sulphuric acid, and yellow with nitric or muriatic acid. Its specific gravity is about 6.12. It does not melt before the blow-pipe, but it becomes black when urged by the interior flame. With glacial acid of phosphorus it produces a transparent blue glass, if the inner part of the flame be directed on them, which loses its colour on being removed to the exterior part of the flame. It neutralizes alkalies, and is thus rendered soluble in water. Ammonia combined with it, or tungstate of ammonia, if dropped into lime-water, instantaneously throws down a precipitate which is tungstate of lime.

METHODS OF OBTAINING TUNGSTIC ACID.

Let one part of powdered tungstate of lime be digested in three of nitric acid, till it acquires a yellow colour. Decant

the acid, and let the remaining yellow powder, after being washed in distilled water, be digested in liquid ammonia till it is rendered considerably whiter. This ammoniacal solution is then poured off, and the residual undecomposed part of the tungstate is once more treated with nitric acid as before. The acid being again separated it is again digested with liquid ammonia, and so on alternately till it is totally decomposed.

The ammoniacal solution is then decomposed by the addition of nitric acid; the tungstic acid becomes precipitated in the form of a white powder, which, after being washed, dried, and exposed to heat, assumes a yellow colour.

RATIONALE...On adding nitric acid to the ammoniacal solution, nitrate of ammonia is formed, and the tungstic acid becomes separated, but this last is not perfectly free from ammonia, it is therefore necessary to heat it, or to wash it in diluted nitric acid, by which means the adhering ammonia is either volatilized or neutralized, which then may be washed away by means of distilled water.

The tungstic acid may also be obtained from the mineral called wolfram, in which it is combined with iron and manganese, and frequently with silicic acid, in the state of a yellow oxide, as directed before, p. 16.

PROPERTIES OF TUNGSTATES.

These salts are very little known. Most of them, when dissolved in water, are decomposed by all the acids: these combinations occasion a precipitate, which is a triple compound, varying according to the acid employed.

METHODS OF OBTAINING TUNGSTATES.

Tungstate of potash, soda, or ammonia, may be formed by dissolving tungstic acid in the alkaline solutions. Tungstate of magnesia is obtained by boiling tungstic acid with carbonate of magnesia.

MOLYBDIC ACID.

PART LXXXVIII.

PROPERTIES OF MOLYBDIC ACID.

MOLYBDIC acid is yellowish white, pulverulent, and has an acid but metallic taste. It remains fixed during an intense heat, as long as the crucible is covered; but the moment it is uncovered the acid rises unaltered in a white smoke. It is soluble in about 570 parts of water at a mean temperature. The solution reddens tincture of cabbage. Paper dipped in this acid becomes of a blue colour, in the sun. Nitric acid has no action upon it. Muriatic acid and sulphuric acid dissolve it by the assistance of heat. The attraction of the molybdena for oxygen in these acids is very feeble, for mere exposure to light; passing through it a current of hydrogen gas, or digesting it with any of the metals, changes its colour to a blue, by partially de-oxidating it.

We are indebted to *Mr. Hatchett* for a thorough knowledge of the properties of this acid and all its combinations.

METHODS OF OBTAINING MOLYBDIC ACID.

Scheele's method of obtaining molybdic acid consists in distilling about 25 or 30 ounces of diluted nitric acid from one ounce of native molybdena at five or more successive operations, that is to say, 4 or 6 ounces of the acid at a time. A great quantity of nitrous gas is obtained, and a white powder remains in the retort, which must be washed in distilled water to free it from the adhering foreign acid.

It may also be obtained by detonating molybdena in a red-heat with nitrate of potash. The residue left after detonation, when 4 parts of the salt to 1 of the metal have been employed, yields a colourless solution that contains the molybdate of potash, and which, upon a proper addition of water, lets fall the molybdic acid in the form of a white powder.

The union of molybdic acid with alcalies, earths, &c. forms salts termed MOLYBDATES.

PROPERTIES OF MOLYBDATES.

These salts are not better known than the last. A few with which we are acquainted, have the property of giving a green colour to phosphate of soda and ammonia when melted with it; and occasion a blue precipitate with muriate of tin.

METHODS OF OBTAINING MOLYBDATES.

The super-molybdate of potash, is the only salt that has been examined with tolerable accuracy. It may be produced by detonating one part of sulphuret of molybdena, with three of nitrate of potash, dissolving the mass in water, filtering the solution and evaporating it. Sulphate of potash first crystallizes, but if sulphuric acid be dropt into the remaining solution, super-molybdate of potash is precipitated.

CHROMIC ACID.

PART LXXXIX.

CHROMIC acid exists in combination with various metals and earths. Combined with oxid of lead, it forms the red lead ore of Siberia, called *chromate of lead*. It has been found united to iron, alumine, and silex, (*chromate of iron*.) Vauquelin has proved that it is the colouring matter of the emerald, &c. It probably exists in other gems.

PROPERTIES OF CHROMIC ACID.

The chromic acid is of a ruby-red colour, and in crystals of a prismatic figure. These are soluble in water, and have a sharp, pungent, and metallic taste. When mixed with filings of tin and muriatic acid, it becomes at first yellowish brown, and afterwards assumes a beautiful green colour. When mixed with a little ardent spirit and nitric acid, it immediately assumes a bluish green tinge, which preserves the same shade even after desiccation. Sulphuric ether gives it the same colour. If paper be dipped in chromic acid, and exposed for some days to the rays of the sun, it assumes a green colour, which does not change in the dark. Muriatic acid, heated in a retort with this acid, produces a strong effervescence, and oxygenated muriatic acid gas is evolved.

Chromic acid, mixed with a solution of the hidro-sulphuret of potash, is precipitated in the form of greenish brown flakes

Tannin precipitates it in flakes of a fawn colour. Heated by the blow-pipe on charcoal, it boils up, and leaves an infusible green matter. Fused with phosphoric acid, or with borax, a vitreous globule is obtained of an emerald-green colour. Sulphuric acid, while cold, produces no effect upon it; but, when heated, it makes it assume a bluish green colour. With a solution of nitrate of mercury, it gives a precipitate of a dark cinnabar red. With a solution of nitrate of silver, it gives a precipitate, which, the moment it is formed appears of a beautiful carmine red, but becomes purple by exposure to light. It unites with the alcalies and forms crystallizable salts of a beautiful orange colour. It also unites with the earths and metallic oxids, and forms compounds distinguished by the splendour of their colours.

METHODS OF OBTAINING CHROMIC ACID.

To obtain chromic acid boil one part of the red lead ore of Siberia, reduced to an impalpable powder, with two parts of carbonate of potash and ten or twelve of water, for at least an hour. Then suffer the mixture to subside, decant and filter the super-natant fluid. The clear solution must then be evaporated and suffered to crystallize. When no more crystals can be obtained in this manner, the whole quantity of salt is to be dissolved in a sufficient quantity of distilled water, and pure nitric acid added to the saturation of the alcali. The solution now affords by evaporation crystals of a ruby colour, which are chromic acid.

In order to disengage chromic acid from chromate of iron the method described page 22 may be made use of.

On account of the scarcity of the minerals which contain this acid, the properties and methods of obtaining *chromates* are still unknown.

COLUMBIC ACID.

PART XC.

COLUMBIC acid exists in the new discovered ore called columbate of iron.

PROPERTIES OF COLUMBIC ACID.

Columbic acid appears in the form of a white pulverulent substance, whose colour does not become changed, when boiled in nitric acid. It is soluble in sulphuric and muriatic acid. The solution in sulphuric acid, when mingled with water, deposits a white precipitate, which, when suffered to dry, acquires first a blue and then a grey colour. All the acid solutions are decomposable by alcalies. Columbic acid has scarcely any perceptible flavour, nor does it appear to be soluble in water; but when moistened with this fluid, and placed in contact with litmus paper, it very soon reddens it. It expels the carbonic acid from carbonated alcalies, and forms salts with potash and soda, which are colourless, soluble in water, permanent in the air, and decomposable by nitric acid. Dissolved in water they form a precipitate, when mingled with solutions of tungstate and molybdate of potash, with cobaltate of ammonia, and alkaline solutions of iron. Columbic acid does not combine with ammonia, nor does it unite with sulphur, by fusion. It forms a purplish blue glass with phosphate of ammonia. For a fuller account of this acid, we refer our reader to Mr. Hatchett's paper in the *Philosoph. Transactions*, 1802, p. I. p. 40. The method this philosopher made use of for separating this acid from its natural combination, has been noticed already, page 24.

Class III....ACIDS COMPOSED OF MORE THAN TWO BASES.

ACETOUS ACID.

PART XCI.

THIS acid exists combined with much mucilaginous and extractive matter, and some portion of acidulous tartrate of potash in the common vinegar. When freed from them, it is called acetous acid, or distilled vinegar.

PROPERTIES OF ACETOUS ACID.

Acetous acid is a perfectly colourless fluid, of an agreeable acidulous odour, and pleasant sour taste, though frequently, (at least when not carefully prepared) it possesses more or less of an empyreumatic flavour. It acts on almost all the metallic substances. Its combinations are attended with a variety of important phenomena, and afford products of the greatest utility in the arts, &c. Its affinity to earths, alcalies, and metallic oxids, is inferior to that of the sulphuric, muriatic, and nitric acids.

METHOD OF OBTAINING ACETOUS ACID.

Acetous acid is formed by the fermentation of wine, on which account it is called vinegar. However, wine is not indispensably necessary for its production as it is found in the urine of animals, &c. The vinegar produced during fermentation is far from being pure acetous acid, but may be obtained so by distillation. For this purpose chuse the strongest vinegar possible, and having introduced it into a glass retort, place it in a sand-heat, or rather in a water-bath. Adapt to the retort a large receiver and lute the joinings. Then apply a gentle heat, and increase it gradually, taking care to cool the receiver with cloths soaked in water. The first portion which passes over is an aqueous fluid; but the acetous acid soon ascends. This is what is called distilled vinegar.

The combinations of acetic acid with different bases form salts, called ACETITES.

PROPERTIES OF ACETITES.

Acetites are decomposable by heat, the acetic acid is either disengaged unaltered, or decomposed. They are likewise decomposed by the affusion of sulphuric acid.

METHODS OF OBTAINING ACETITES.

Acetite of potash, soda, barytes, strontia, or lime, may be obtained by neutralizing the carbonates of these alcalies with acetic acid, evaporating the solution and crystallizing it. Acetite of lime or magnesia may be obtained in a direct manner. Acetite of silver is produced by dropping acetite of potash into a solution of nitrate of silver. Acetite of mercury is produced in a similar manner from nitrate of mercury, and acetite of potash. Acetite of iron, lead, zinc, and nickel, may be produced by dissolving these metals in acetous acid, evaporating the solutions and suffering them to crystallize.

ACETIC ACID.

PART XCII.

THE acetous acid, deprived of part of its carbon, changes its nature; it acquires new properties, and then constitutes what is called acetic acid. The difference between the acetous and acetic acid does not depend, as was formerly supposed, on a different degree of oxigenation, but on the different proportions of carbon, which enter into its composition.

PROPERTIES OF ACETIC ACID.

Acetic acid has a more pungent sour smell than acetous acid. Its odour is so penetrating that when very concentrated it is impossible to support it for any length of time, it is even caustic and capable of corroding the skin. It is extremely volatile.

METHOD OF OBTAINING ACETIC ACID.

Take one part of acetate of potash, put it into a tubulated retort, lodged in a sand-heat, and pour gradually upon it half its weight of sulphuric acid. A violent action takes place, and part of the acetic acid becomes liberated in the form of white vapours. After the spontaneous action has ceased, distil with a gentle heat, and acetic acid will be obtained in considerable quantity.

OXALIC ACID.

PART XCIII.

PROPERTIES OF OXALIC ACID.

OXALIC acid is always concrete; its crystals are quadrilateral prisms, having their sides alternately broad and narrow, and terminating in two-sided summits. It is particularly distinguished by its strong attraction to lime, which is superior to that of any other acid. It is not altered on exposure to air. It acts upon most of the metals. Exposed to heat it becomes decomposed into carbonic acid, and carbonated hydrogen gas. It contains more oxygen than any other vegetable acid.

METHOD OF OBTAINING OXALIC ACID.

Oxalic acid is generally prepared by oxygenating sugar, in the following manner: Put one part of white sugar into a retort, and pour over it four parts of nitric acid, of about 1.567 spec. grav. adapt a receiver, and make the solution boil. When the fluid in the retort acquires a brown colour, add three parts of acid more, and continue the boiling till it again becomes brown, then add two parts more of acid, and continue the heat till the red fume almost disappears. Having done this,

suffer the mixture to crystallize. After having removed the obtained crystallized acid, the residue may again be treated in a similar manner as before, until no more crystals are obtained. It may then be purified by dissolving it in water, and re-crystallizing it repeatedly.

Oxalic acid united to alcalies, earths, &c. forms salts, called OXALATES.

PROPERTIES OF OXALATES.

The soluble salts formed by the union of oxalic acid with different bases, are decomposable by lime-water, the precipitate produced is soluble in acetous acid. Most of the alkaline oxalates are capable of combining with an excess of acid. The terrene oxalates are in general nearly insoluble, they are however all decomposable by a red heat.

METHODS OF OBTAINING OXALATES.

Oxalate of ammonia may be obtained by carefully saturating oxalic acid, dissolved in water, with carbonate of ammonia, and suffering the fluid to crystallize as soon as a pellicle appears. Oxalate of potash, or soda, may be obtained in a similar manner. Oxalate of lime is produced by letting oxalic acid fall into lime-water; the salt instantly becomes precipitated. Oxalate of strontia is formed by mingling a solution of oxalate of potash with nitrate of strontia; the oxalate of strontia precipitates instantly. Oxalate of barytes may be produced by dissolving barytes in oxalic acid to saturation.

TARTAREOUS ACID.

PART XCIV.

TARTAREOUS acid exists in the juices of many vegetables, generally combined with lime.

PROPERTIES OF TARTAREOUS ACID.

Tartareous acid appears in the form of tabular crystals. Its taste is exceedingly sour. It is not altered by the air. It readily dissolves in water. It takes lime from the nitric, muriatic, phosphoric, and acetic acids. It has a strong tendency to unite to potash. In one proportion it forms a soluble salt, (tartrate of potash), but when the acid is in excess it forms a salt of difficult solubility, (acidulous tartrate of potash.) It is on this account that the presence of tartareous acid in any solution may easily be detected.

METHODS OF OBTAINING TARTAREOUS ACID.

To obtain tartareous acid, dissolve thirty-two parts of acidulous tartrate of potash in water, and throw chalk into it gradually till it is completely saturated, a precipitate will be formed which is *tartrate of lime*; decant the fluid, and put the tartrate of lime into a matrass, pour over it nine parts of sulphuric acid and five of water; digest the whole for six hours, taking care to stir it from time to time; the tartareous acid will then remain free, and may be separated, by means of cold water, from the sulphate of lime which has been formed, and crystallized by suffering it to evaporate slowly.

REMARK...To ascertain whether the tartareous acid contains sulphuric acid, let fall into it a few drops of acetite of lead: if the precipitate, which is formed, be entirely soluble in acetic

acid, the fluid contains no sulphuric acid; if it is not soluble, sulphuric acid is present: to free it from this the fluid must again be digested over another quantity of the tartrate of lime.

The salts formed by means of tartareous acid, are called **TARTRITES**.

PROPERTIES OF TARTRITES.

All the tartrites are decomposable by a red heat, the basis is left behind in the state of a carbonate. They are decomposable by sulphuric acid. They are capable of combining with an excess of acid, forming salts, called super-tartrites. Most of them are also capable of combining with another base, in order to form triple salts.

METHODS OF OBTAINING TARTRITES.

Tartrate of potash, soda, or ammonia, is formed by dissolving the carbonates of these alkalies in tartareous acid, to saturation, and evaporating the solutions as directed so frequently before. Tartrate of strontia is precipitated by mingling a solution of nitrate of strontia with a solution of tartrate of potash. Tartrate of potash and lime is produced by dropping tartrate of potash into lime-water. Tartrate of potash and barytes, and tartrate of potash and strontia, are formed in a similar manner. Tartrate of potash and soda is produced by neutralizing a solution of acidulous tartrate of potash with carbonate of soda. Tartrate of potash and ammonia is obtained by mixing a solution of acidulous tartrate of potash with carbonate of magnesia. Tartrate of silver is produced by dropping a solution of nitrate of silver into a solution of acidulous tartrate of potash. Tartrate of mercury is precipitated by letting fall tartareous acid into a solution of nitrate of mercury. In a similar manner, tartrate of lead and tartrate of bismuth are formed. Tartrate of iron and tartrate of copper are produced by decomposing in a like manner, a solution of sulphate of copper, or sulphate of iron.

CITRIC ACID.

PART XCV.

CITRIC acid exists in the juice of lemons and oranges; in unripe grapes, cranberries, bilberries, and a variety of other sour fruits.

PROPERTIES OF CITRIC ACID.

Citric acid crystallizes in the form of rhomboidal prisms, which suffer no alteration from exposure to air. They are easily dissolved by water, and excite a very sour taste, which, when diluted, is exceedingly pleasant. One part of boiling water dissolves two of citric acid. It acts upon iron, zinc, tin, lead, and various other metals. Treated with nitric acid it becomes converted into oxalic and acetic acid. Exposed to a red heat, it becomes decomposed into carbonic acid, and carbonated hydrogen gas, and a little charcoal remains behind.

METHOD OF OBTAINING CITRIC ACID.

Saturate any quantity of boiling lemon juice, by adding to it gradually, pure chalk, in small quantities, until the effervescence ceases, on adding to it a new portion of chalk. During this process a white precipitate will be formed, and fall down to the bottom, consisting of citric acid and lime, (citrate of lime.) Separate this precipitate by transferring the whole on a strainer, and pour water over it till this fluid passes tasteless. Transfer the washed precipitate into a matrass, or other convenient vessel, and pour over it as much sulphuric acid as will neutralize the chalk employed, having previously diluted the acid with six times its weight of water. Boil the whole about half an

hour, agitating it with a wooden spatula during the whole time, and then pour it on a filter, taking care to return the fluid, which passes through, back upon the filter until it becomes perfectly clear. Having done this, evaporate the fluid in a shallow vessel to the consistence of a thin syrup, and leave it to crystallize undisturbed. The crystals obtained are citric acid; in order to obtain them in a state of purity they must be re-dissolved, the solution must be filtered, and re-crystallized repeatedly.* Four parts of chalk require in general, for saturation, 94 parts of lemon juice. The citrate of lime produced amounts to about $7\frac{1}{2}$ parts. To decompose this, nearly 20 parts of sulphuric acid are necessary.

The combination of citric acid with different bases, forms the salts called CITRATES.

PROPERTIES OF CITRATES.

All the salts consisting of citric acid, when dissolved in water, are decomposable by the addition of tartareous and oxalic acid. They are likewise decomposed by sulphuric, nitric, and muriatic acids. A solution of barytes, mingled with a solution of citrate of potash, soda, or ammonia, produces an insoluble precipitate.

METHODS OF OBTAINING CITRATES.

Citrate of soda, ammonia, lime, potash, or magnesia, may be formed by dissolving the carbonates of these substances in citric acid, and evaporating the solution. The two latter do not crystallize. Citrate of barytes is precipitated by adding a solution of barytes to citric acid. Citrate of strontia is produced by dropping a solution of nitrate of strontia into citrate of ammonia. Citrate of iron and citrate of zinc may be formed by dissolving these metals in citric acid, and subsequent evaporation and crystallization. Citrates of silver, mercury, and lead, are obtained in a similar manner from the oxids of these metals.

U 3

* Mr. Coxwell who has established a manufacture of citric acid, prepares it in a state of absolute purity; and at so cheap a rate as was formerly thought impossible to procure it.

MALIC ACID.

PART XCVI.

THIS acid is found in the juice of unripe apples, and in those of barberries, elder-berries, gooseberries, plumbs, and the common house-leek.

PROPERTIES OF MALIC ACID.

Malic acid cannot be obtained in a crystalline form, but appears always in the liquid state. Its taste is an unpleasant sour. If left exposed to the air it gradually undergoes a spontaneous decomposition. Nitric acid converts it into oxalic acid.

METHODS OF OBTAINING MALIC ACID.

1. Take the juice of apples, saturate it with potash, and then add a solution of acetite of lead till it no longer occasions a precipitate; wash this precipitate, which is malate of lead; pour over it sulphuric acid till the liquor acquires an acid taste without any mixture of sweetness, and filter the whole, in order to separate the malic acid from the sulphate of lead which is formed.

2. Malic acid is also obtained by adding to the expressed juice of house-leek, a solution of acetite of lead, till no further precipitate ensues. The precipitate, after being washed, may be decomposed by sulphuric acid as before.

3. Malic acid may likewise be produced by distilling equal quantities of nitric acid and sugar, till the solution acquires a brown colour. The sugar is thus partly converted into oxalic and partly into malic acid. The oxalic acid may be separated by mingling the solution with lime-water, until no farther precipitate ensues; the malic acid is then left behind. In order to obtain it in a pure state neutralize it with lime, filter the solution, and mix it with alcohol. A coagulation now takes place, for the water separates, and the malic acid, united to the lime, may be obtained by filtration. Having done this let it be dissolved in water, and add to it a solution of acetite of lead until no farther precipitate ensues. This precipitate which is malate of lead, may be decomposed by sulphuric acid, as before directed.

Malic acid united to different bases, forms the salts called MALATES.

PROPERTIES OF MALATES.

These salts are little known, they have been examined superficially by Scheele only. The malates of potash, soda, and ammonia are deliquescent. Malates of lime, barytes, and magnesia, are very insoluble.

METHODS OF OBTAINING MALATES.

Malate of potash, soda, ammonia, lime, or barytes, may be formed by dissolving these alcalies in malic acid, and evaporating the solutions.

GALLIC ACID.

PART XCVII.

GALLIC acid exists in the gall-nut, in the husk of nuts, in oak bark, and in all those vegetables commonly called astringents.

PROPERTIES OF GALLIC ACID.

Gallic acid appears in the form of minute needle-shaped crystals. Its taste is sour, and austere or astringent. It strongly reddens blue vegetable colours. It is soluble in about 10 parts of cold, and in three of boiling water. It is not altered by exposure to air. Exposed gradually to a gentle heat it sublimes without alteration, but if exposed to a strong heat, quickly applied, it becomes decomposed into carbonic acid, and carbonated hydrogen gas. It has a strong tendency to unite with metallic oxids. With the red oxid of iron it produces a deep black precipitate. This combination is the basis of ink and black dyes.

METHODS OF OBTAINING GALLIC ACID.

For the following method of obtaining gallic acid we are indebted to Mr. Fiedler.*

1. Dissolve two ounces of alum of commerce in water, and precipitate the solution, by letting fall into it a solution of pot-

* Nicholson's Journal, vol. I. No. 3, p. 236.

ash; wash the precipitate well, and transfer it into an aqueous infusion of gall-nuts (obtained by infusing 1 oz. of galls in 16 of water, and evaporating the infusion to one half), agitate the mixture frequently during the course of 24 hours, and transfer it on a filter. The fluid which passes through the filter is gallic acid; it may be obtained in the form of needle-shaped crystals by evaporating it slowly, till a pellicle appears, and then letting it stand undisturbed.

2. Gallic acid may also be obtained, according to Scheele, in the following manner: Reduce a pound of nut-galls to powder, and pour upon it six pounds of distilled water: Leave this mixture to macerate for the space of 15 days at a temperature of from 68° to 77° . Then filter this liquor; and after the filtration, expose it in a vessel of glass or stone-ware, to evaporate slowly in the air. During this evaporation, which may be continued during two or three months, the gallic acid will be deposited in crystals, on the sides and bottom of the vessel, and on the inferior surface of a pellicle which will have formed over the mixture. At the end of this period, pour off the liquor. Then dissolve whatever remains in the vessel in alcohol. This last solution, evaporated, will afford the gallic acid in crystals.

3. Gallic acid may likewise be obtained by exposing powdered nut-galls in a retort to a moderate heat. The acid by this means sublimes; part condenses in small white crystals, and part is obtained in a fluid form, from its combination with a portion of water contained in the galls.

REMARK...This process requires a great deal of precaution; the fire must be gradually raised, and slackened the moment coloured drops fall from the beak of the retort, otherwise the whole product becomes dissolved again, and is lost.

Gallic acid, united to different bases, forms salts called GALLATES. They have not hitherto been examined.

SUCCINIC ACID.

PART XCVIII.

SUCCINIC acid exists in a bituminous substance, called amber, which is of a yellow colour, takes a fine polish, and is electric. It is found principally on the sea-coast in Prussia.

PROPERTIES OF SUCCINIC ACID.

Succinic acid exists in a solid form. Its crystals are colourless, four-sided oblique plates, which are permanent in the air. It has a strong acid taste. It is soluble in 24 parts of cold, and in two of boiling water. It is slightly soluble in alcohol. It is volatilized by heat.

METHOD OF OBTAINING SUCCINIC ACID.

Fill a matrass half full of amber, lute to it an alembic, and distil with a gradual heat, till drops of oil fall from the beak of the alembic. Then separate the solid acid which has sublimed, dissolve it in water, filter the solution, and suffer it to crystallize. Repeat these latter operations till the salt is nearly colourless.

The salts formed by succinic acid are termed **SUCCINATES**. Their properties are very little known.

METHOD OF OBTAINING SUCCINATES.

Succinate of potash, soda, ammonia, or lime, may be obtained, by dissolving these alcalies to saturation in succinic acid, evaporating the solution, and setting it aside to crystallize. Succinate of magnesia is obtained in a similar manner, but it does not crystallize.

BENZOIC ACID.

PART XCIX.

BENZOIC acid exists in considerable quantity in the concrete resin, termed benzoin; in Peruvian balsam; in balsam of Tolu, liquid storax, and other odoriferous substances of a similar nature. It also exists in human urine, and in that of cows; in the blood; in the albumen of eggs; in glue, silk, wool, sponge, and in mushrooms.*

PROPERTIES OF BENZOIC ACID.

Benzoic acid exists in the form of fine white light crystals, which are not brittle, but rather ductile. Its taste is not very predominant, but irritating and vivid. When perfectly pure it is totally void of odour. It is sparingly soluble in cold, but abundantly in hot water, and very soluble in alcohol, and in sulphuric and nitric acid. It is unalterable by air and volatilizes in a moderate heat. It burns when placed on ignited charcoal, and detonates with nitrate of potash.

* Annales de Chim. xxxvi, p. 272.

METHODS OF OBTAINING BENZOIC ACID.

Benzoic acid is best obtained by boiling repeatedly four parts of powdered benzoin with one of lime, in four parts of water, filtering the solution, and adding to it muriatic acid, till no further precipitate ensues. The precipitate obtained is benzoic acid. It may be purified by repeated solutions, filtrations, and crystallizations.

Benzoic acid may also be obtained by exposing benzoin in a crucible to a gentle heat, and covering the crucible with a cone of blotting paper. The acid sublimes and affixes itself to the paper.

The salts which this acid forms are called BENZOATES. Their properties are little known.

METHOD OF OBTAINING BENZOATES.

Benzoate of potash, soda, ammonia, barytes, or lime, may be obtained by neutralizing benzoic acid with these alcalies, evaporating the solution and suffering them to crystallize. Benzoate of alumine and magnesia are produced in a similar manner.

CAMPHORIC ACID.

PART C.

PROPERTIES OF CAMPHORIC ACID.

CAMPHORIC acid exists in the form of white crystals which effloresce in the air. Its taste is acid and somewhat bitter. It strongly reddens vegetable blues. It has little or no odour. It is very volatile; it is soluble in water, in alcohol, in sulphuric, nitric, and muriatic acid.

METHOD OF OBTAINING CAMPHORIC ACID.

Put into a retort one part of camphor and eight of nitric acid, distil the mixture, and repeat it three times on the same residue with a like quantity of acid; after the last distillation is accomplished, crystals will be found in the retort, which are camphoric acid.

The salts formed by camphoric acid with different bases, are denominated CAMPHORATES.

PROPERTIES OF CAMPHORATES.

All the camphorates known are easily decomposable by heat; urged with the blow-pipe they burn with a blue flame. Their taste is a saline bitter.

METHODS OF OBTAINING CAMPHORATES.

Camphorate of potash, soda, or ammonia, may be obtained by neutralizing these alcalies with camphoric acid, evaporating the solution and suffering it to crystallize. Camphorate of lime and alumine may be produced in a similar manner.

MUCOUS,
OR
SACCHO-LACTIC ACID.

PART CI.

THIS acid was discovered by Scheele, who obtained it by treating sugar of milk with nitric acid. Hence he called it saccho-lactic acid.

PROPERTIES OF MUCOUS ACID.

Mucous acid exists in the form of a white gritty powder. It is sparingly soluble in water, but more soluble in alcohol. Its taste is slightly acid, but it sensibly reddens tincture of cabbage. It scarcely acts upon any of the metals. It forms soluble salts with potash, soda, or ammonia; but insoluble compounds with most of the rest of the alcalies and earths.

METHODS OF OBTAINING MUCOUS ACID.

Take one part of gum arabic reduced to powder, put it into a retort, and pour over it two parts of nitric acid; heat the mixture gradually, keep it boiling for about a quarter of an hour, and then suffer it to cool; a white powder will separate, which after being washed is mucous acid.

Mucous acid may be obtained, by treating sugar of milk with nitric acid, in a similar manner.

The compounds formed of mucous acid have been but little investigated.

SUBERIC ACID.

PART CII.

SUBERIC acid exists in *cork*, a substance well known.

PROPERTIES OF SUBERIC ACID.

Suberic acid may be produced in a solid form. It is volatilized by heat. It has a sharp acid bitterish taste, it acts strongly upon the throat and excites coughing. It strongly reddens vegetable blues, and has the peculiar property of turning the blue solution of indigo in sulphuric acid to green. It is difficultly soluble in cold, but easily soluble in boiling water. When urged by the heat of a blow-pipe, it fuses, becomes dry, and at last sublimes entirely.

METHOD OF OBTAINING SUBERIC ACID.

Introduce one part of cork cut into small pieces into a retort, and pour upon it six of nitric acid, distil the mixture with a gentle heat till no more nitrous gas appears. Then pour the contents into a bason, and evaporate it till it acquires the consistence of honey, and a pungent suffocating vapour arises; then add to it twice its bulk of boiling water, heat it gently and pour it on a filter. The fluid which passes, when cooling, deposits a precipitate, which must be separated; the fluid is then evaporated to dryness, and the product obtained is suberic acid.

The union of suberic acid with different bases constitutes the salts called SUBERATES. They have no marked properties except a bitter taste.

PRUSSIC ACID.

PART CIII.

THIS acid derives its name from the pigment called Prussian blue, of which it forms a component part.

PROPERTIES OF PRUSSIC ACID.

Prussic acid exists in the form of a colourless fluid. It has a strong odour greatly resembling that of peach-tree flowers, or of bruised bitter almonds. Its taste is sweetish but acrid. It is very volatile and inflammable when in the state of vapour or gas. It does not redden the most delicate vegetable blues. It is easily decomposable at high temperatures, and becomes converted into ammonia, carbonic acid, and carbonated hydrogen gas. It does not act upon any of the metals, but readily unites with most of their oxids. It has a great tendency to form triple compounds with alcalies and metallic oxids, and in that state it decomposes all metallic salts, and hence it is one of the most important reagents of the chemist.

METHOD OF OBTAINING PRUSSIC ACID.

The process is as follows: Put into a glass matrass two parts of pulverized Prussian blue, one part of red oxid of mercury,

and six parts of water; boil this mixture for half an hour, agitating it frequently, then filter it, and pour over the residuum two parts more of boiling water, and having united the liquors, evaporate the whole to obtain crystals.

RATIONALE... The prussic acid quits the oxid of iron to unite to the oxid of mercury, with which it forms prussiate of mercury, which can neither be decomposed by acids nor alcalies. In order to disengage from it the prussic acid, dissolve it in water, or take the liquor above mentioned not concentrated: pour the quantity obtained in the preceding experiment, into a bottle containing about an ounce of iron filings, add nearly three ounces of concentrated sulphuric, or muriatic acid, and shake it well for some minutes: the mixture now becomes black, for the iron unites to the oxygen of the mercury, and combines with the acid. Leave the fluid at rest, and then decant it, and put it into a retort placed on a sand-bath; adapt to the retort a receiver, containing a little distilled water, to absorb the acid, and carefully lute all the joinings. By the help of a gentle heat the prussic acid, -being more volatile than water, will pass over first; and when about a fourth of the liquor has passed, stop the operation.

The liquor which passes contains a little sulphuric acid: to free it from this acid, distil it again with a very gentle heat from pulverized chalk, and prussic acid will be obtained in the greatest purity.

Prussic acid may also be obtained by putting prussiate of potash and iron into a tubulated retort, and adding to it gradually sulphuric or muriatic acid, and heating the mixture; the prussic acid becomes disengaged, and is absorbed by the water previously put into the receiver.

The combination of prussic acid with different bases forms salts called **PRUSSIATES**.

PROPERTIES OF PRUSSIATES.

These salts have been little examined, probably on account of the difficulty which attends their formation, and the spontaneous decomposition they suffer. All that is known concerning them is, that they are very easily decomposed by all acids, and also by a mere exposure to vivid light, or to a heat of about 110° . All the metallic prussiates are insoluble, except prussiate of mercury and manganese. These compounds are not decomposable by acids. The triple prussiates are the salts which have been most particularly examined, on account of the important action they exercise upon other bodies.

METHODS OF OBTAINING PRUSSIATES.

Prussiate of potash and iron. The best methods of preparing this important salt are the following:

Prepare pure potash, as directed before, page 229, &c.

Dissolve it in five times its weight of water, and pour this solution into a glass receiver, placed in a sand-bath, heated to 170° or 180° , and then gradually add the best Prussian blue in powder, injecting new portions, as the former becomes discoloured, and supplying water as fast as it evaporates, until the last added portions of Prussian blue are no longer discoloured; then increase the heat to boiling, and continue it for half an hour. Filter the ley thus obtained, and saturate it with sulphuric acid moderately diluted; a precipitate will appear: when this ceases, filter off the whole, and wash the precipitate.

Evaporate the filtered fluid to about one quarter, and set it aside to crystallize: after a few days, yellowish crystals of a cubic or quadrangular form will be found mixed with some sulphate of potash and oxid of iron; pick out the yellowish crystals, lay them on blotting paper, and re-dissolve them in four times their weight of cold water, to exclude the sulphate of potash.

Having done this, essay a few drops of this solution with barytic water, to see whether it contains any sulphuric acid, and add some barytic water to the remainder if necessary; filter off the solution from the sulphate of barytes, which will have precipitated, and set it by to crystallize for a few days, that the barytes, if any should remain, may be precipitated. If the crystals now obtained be of a pale yellow colour, and discover no bluish streaks, when sprinkled over with muriatic acid, they are fit for use; but if they still discover bluish or green streaks, the solution and crystallization must be repeated.

These crystals must be kept in a well-stopped bottle, which, to preserve them from the air, should be filled with alcohol, as they are insoluble in it.

Another good method of preparing this salt has been lately given by Mr. W. Henry.* It consists in first forming a triple prussiate of barytes, and adding it in crystals to a solution of carbonate of potash, till the solution no longer restores the colour of reddened litmus paper. After digesting the mixture for half an hour, filter the liquid and evaporate it gently. The triple prussiate of potash crystallizes.

Triple prussiate of potash, when pure, forms fine transparent crystals of a yellow colour; they have the form of cubes or parallelopipeds, and contain, when prepared according to the first method, 0.24 parts of oxid of iron.

REMARK. This salt or its solution in water, is the most useful test ever discovered, for by means of it we are enabled to ascertain whether any metallic substance is present in any solution; for it precipitates all metals (*platina* excepted) in the form of a coloured powder, from the colour of which we may learn what metal was present in the solution, and from the proportion, its respective quantity. But in order to be accurate in this respect, the test employed must itself either be free from

X 2

* Nicholson's Journal, iv. 31:

iron, or the quantity it contains must be known. The first object has hitherto failed, the latter may be accomplished in the following manner: Take 100 grains of the triple prussiate, obtained as before, heat it to redness for half an hour in an *open* crucible: it will thus be consumed, and the iron will remain in the state of a reddish brown magnetic oxid; this must be weighed, and the weight noted down. This oxid is half the weight of the Prussian blue which the test would afford: its weight must therefore be subtracted from that of the precipitate formed by the test. Hence the weight of the crystals, in a given quantity of the solution, should be noted, that the quantity employed in precipitation may be known. Care must be taken to continue the heat till the oxid of iron becomes brown; for while it is black it weighs considerably more than it should.

Prussiate of lime and iron may be obtained by boiling two parts of Prussian blue, in about 56 of lime-water, for about $\frac{1}{4}$ of an hour, till the prussic acid is neutralized with the lime, which will be known by its not altering the colour of turmeric paper. *Prussiate of barytes and iron* is best prepared according to Henry's method, by adding Prussian blue to hot barytic water, till a new portion added ceases to be discoloured; the solution may then be filtered, evaporated, and crystallized. *Prussiate of strontia and iron* is produced in a similar manner. *Prussiate of iron*, or Prussian blue, is prepared by igniting, with a moderate heat, 3 parts of dried blood and 2 of carbonate of potash. From this mass a ley is obtained, by the affusion of water. This is mingled with a solution of one part of sulphate of iron of commerce, and two of alum; a green precipitate is formed, which, when washed with diluted muriatic acid, assumes a beautiful blue colour.

LACTIC ACID.

PART CIV.

THIS acid exists in the *whey* of milk.

PROPERTIES OF LACTIC ACID.

Lactic acid is capable of existing in the solid state; but it greatly attracts moisture, and becomes liquid. It has a sour taste. It strongly oxidates iron, zinc, copper, and various other metals.

METHOD OF OBTAINING LACTIC ACID.

Take any quantity of whey, evaporate it very slowly to one eighth, filter it, and then add to it lime-water till no farther turbidness appears. Filter the mixture again, and let fall into the fluid, diluted with water, a solution of oxalic acid, till it produces no further cloudiness. Then filter it and evaporate the fluid to the consistence of syrup, and mingle it with alcohol. Having done this separate the fluid again by filtration, add to it a small quantity of water, put it into a retort, and distil off the spirit; the remaining water then contains the lactic acid in a pure state.

The combination of lactic acid, with different bases forms salts called LACTATES. They have not as yet been examined with accuracy.

SEBACIC ACID.

PART CV.

PROPERTIES OF SEBACIC ACID.

SEBACIC acid exists in a concrete form. It crystallizes in needles. It is void of odour. Its taste is slightly acid. When heated it liquefies like tallow. It is soluble in cold water. Boiling water dissolves it very readily. It is also soluble in alcohol. It precipitates the acetites and nitrates of silver and mercury.

METHODS OF OBTAINING SEBACIC ACID.

Distil hog's lard, wash the product with hot water, and drop into it a solution of acetite of lead, till it occasions no further precipitate. Collect this precipitate, wash it, and dry it. Having done this, pour over it sulphuric acid and heat it; a substance resembling fat will then appear on the surface. This, being collected, dissolved in boiling water, and suffered to cool, crystallizes, and is sebacic acid.

The combination of sebacic acid with different bases, forms the salts called SEBATES. Sebate of potash, soda, ammonia, or lime are crystallizable.

LACCIC ACID.

PART CVI.

THIS acid has been discovered by Dr. Pearson, in a wax-like substance called *white lac*, formed by certain insects of the *coccus* tribe. By exposing this substance to such a degree of heat as was just sufficient to liquify it, a fluid was obtained to which the Doctor has given the name of laccic acid.

PROPERTIES OF LACCIC ACID.

Laccic acid naturally exists in the fluid state. Its specific gravity Dr. Pearson found to be 1,025. at 60°. It strongly reddens paper stained with litmus. It has a saline bitter taste. When heated it smells precisely like newly-baked hot bread. On suffering it to be exposed to the atmosphere it becomes turbid.

BOMBIC ACID.

PART CVII.

THE phalæna, or moth of the silk-worm, particularly when in the state of a chrysalis, contains an acid liquor, said to be of a peculiar nature. This acid is obtained by squeezing the juice of the chrysalis through a cloth, and precipitating the mucilage by the admixture of alcohol. Or, it may be obtained by digesting the chrysalis in alcohol, mixing the infusion with a little water, and subtracting the alcohol by a gentle heat. The acid thus obtained is of an amber colour. It affords prussic acid when distilled with nitric acid. Its other properties and combinations are hitherto little known.

AMNIOTIC ACID.

PART CVIII.

VAUQUELIN and Buniva have discovered a peculiar acid in the liquor of the amnios of the cow, to which they have given the name of amniotic acid.

PROPERTIES OF AMNIOTIC ACID.

Amniotic acid exists in the form of a white pulverulent powder. It is slightly acid, but sensibly reddens vegetable blues. It is difficultly soluble in cold, but readily soluble in boiling water, and in alcohol. When exposed to a strong heat it exhales an odour of ammonia and of prussic acid. Assisted by heat it decomposes carbonate of potash, soda, or ammonia. It produces no change in the solutions of silver, lead, or mercury, in nitric acid. Exposed to heat, it yields ammonia and prussic acid.

Amniotic acid may be obtained by evaporating the liquor of the amnios of the cow to a fourth part, and suffering it to cool, crystals of amniotic acid will be obtained in considerable quantity.

Whether this acid exists in the liquor of the amnios of other animals is not yet known.

URIC ACID.

PART CIX.

THIS acid exists in the urinary calculi, and also in human urine. That species of calculus which resembles wood in its colour and appearance, consists almost entirely of uric acid. It was formerly called lithic acid, a name now superseded by the judicious remarks of Dr. Pearson, to whom we are indebted for a thorough knowledge of it.

PROPERTIES OF URIC ACID.

Uric acid crystallizes in thin plates. It has very little taste or odour. It is insoluble in cold, but soluble in 300 parts of boiling water, it then reddens delicate vegetable blues. It is not acted upon by muriatic acid. Sulphuric acid, assisted by heat, decomposes it. It is soluble in nitric acid, and communicates to it a pink colour. The solution tinges animal matter of the same colour. It combines readily with alcalies and earths, and forms salts, which are decomposable by most of the other acids. The combination of uric acid with potash or soda, forms compounds nearly void of taste. The last is found crystallized in the human body, forming the gouty concretions of those afflicted with the gout.

The acids called Formic and Zoonic are nothing more than acetic acid.

CHEMISTRY OF VEGETATION.

GENERAL VIEW
OF
THE CHEMICAL PHENOMENA.
OF
VEGETATION.

STRUCTURE OF PLANTS.

VEGETABLES are organized bodies, which are nourished by certain substances, received by and prepared within their vessels. They are all produced from seeds. They grow on the earth; at the bottom and on the surface of the ocean, and other waters; and *parasitical* upon other vegetables.

The structure of vegetables is nearly the same in all of them. They are composed of three principal parts, namely, the BARK, the WOOD, and the PITH. The *bark* is the outermost part: it covers the whole body of the plant or tree. On examining it minutely, it will be found to be also composed of three distinct substances, called the *epidermis*, the *parenchyma*, and the *cortical layers*. The *epidermis* is a very thin transparent membrane which covers the whole outer part of the bark. The *parenchyma* is placed below it: it is a succulent green membrane of a retiform texture. The *cortical layers* are the undermost: they consist of several thin membranes, composed of a multitude of lon-

gitudinal fibres, which cross each other, and form a kind of network. The *wood* lies under the bark; it constitutes by far the greatest part of the tree or vegetable. It consists of concentric layers, which are composed of longitudinal fibres. The *pith* is situated in the centre of the wood: it is a very spongy substance, and contains a vast number of cells. Through all these different parts of the plant, vessels are abundantly distributed, by means of which the functions necessary for the life and re-production of the vegetable are carried on. The conditions necessary for that purpose constitute the chemical phenomena of vegetation.

PHENOMENA OF VEGETATION.

If a seed, which consists of three principal parts, namely, the *cotyledons*, the *radicle*, and the *plumula*, is placed in a situation favourable to its vegetation, it absorbs moisture, swells, and becomes soft. The *radicle* is converted into a root, and penetrates into the earth. The *cotyledons* emerge above the ground, and expand in the form of leaves, (called the *seminal leaves*); and the *plumula* becomes the stem, to which the leaves are affixed. The whole seed, during this time, changes to a substance of a saccharine nature, which serves for the first food of the plant. When these appearances take place the seed is said to *germinate* or *grow*. The food which was laid up in the seed for the embryo plant is then exhausted, and the plant derives its future nourishment principally from the air and soil.

FOOD OF PLANTS.

The food of plants consists of water impregnated with vegetable and animal matter, and several gases; but water and air form the principal part of the food of every vegetable. They are decomposed in the vessels of the plant. The hydrogen of the water is retained; the oxygen is also absorbed, but the greatest part of it appears to be evolved again by the leaves. Water also serves to

supply plants with carbonaceous matter, which it diffuses through the leaves, &c. and the same principle is absorbed from the air in the form of carbonic acid gas. These are the only sources whence the charcoal, contained in vegetables which grow in water and air, can be derived. The influence of heat and light are well known to be also very essential to the life of plants.

The manner in which the functions of vegetables are carried on is hidden from our view; they appear to be analogous to the organization and nourishment of animals, and therefore belong to the science of physiology.

IMMEDIATE PRINCIPLES OF VEGETABLES.

The immediate parts of vegetables which are obtained by simple, easy, and frequently mechanical extractions, and which constitute every kind of vegetable matter, are MUCILAGE, or GUM; STARCH, or FECULA; JELLY; SUGAR; GLUTEN; FIXED OIL; VOLATILE OIL; CAMPHOR; WAX; RESIN; EXTRACT; CAOUTCHOUC; ACIDS, TANIN; COLOURING MATTER; SUBER; and WOOD, or LIGNEOUS FIBRE.

MUCILAGE, OR GUM. This substance is void of odour and taste. It is not fusible nor volatile. It is soluble in water, but not in alcohol or oils. It suffers no change on being exposed to air. Its solution in water is adhesive, and used as a paste. Nitric acid converts it into mucous acid, (page 318). It is found in all young plants, and often exudes spontaneously from certain trees; the species of *mimosa* are the most productive, particularly the *nilotica*. Gum arabic, and wild cherry-tree and plumb-tree gum exhibit samples of this kind. Cruikshank obtained from gum, exposed to heat in a close vessel, mucous acid, carbonic acid, hydro-carbonate and ammonia; the residuum consisted of charcoal containing lime. Its principles are consequently oxygen, hydrogen, carbon, nitrogen, and lime.

STARCH, OR FECULA, constitutes the chief part of all the nutritive grains. Barley consists almost entirely of it. It appears in the form of a light, white, insipid, inodorous powder, soft to the touch. It is insoluble in cold, but easily soluble in boiling water, with which it forms a thick paste; which, when dried, assumes the appearance of a semi-transparent jelly, soluble again in hot water. Nitric acid converts it into oxalic and malic acid. It is inflammable. Starch may be extracted from wheat, rye, potatoes, &c. by beating or kneading the flour of the substances with a large quantity of water. This fluid takes up the finest part of the starch, and deposits it again; the water is then decanted, and the starch is suffered to remain in the water till it becomes sour; it is then washed repeatedly and dried. It is a ternary compound of carbon, hydrogen, and oxygen.

JELLY has a tremulous consistence. It is easily soluble in hot but difficultly so in cold water; when strongly boiled for some time it loses the property of gelatinizing.* It has a pleasant taste, and is always coloured by the fruit from which it is obtained. When dried, it becomes transparent like glue. It is obtained by pressing out the juice of ripe fruits, allowing it to repose, and boiling it up and straining it through flannel. The juice of blackberries, currants, gooseberries, &c. combined with sugar and gelatinized is well known.

SUGAR. Its properties are well known. It is very extensively diffused throughout vegetables; the juice of the sugar-cane, affords it in abundance: it is likewise obtained from the sugar maple; from the beet-root, &c. The process for the preparation of sugar is, to press the juice, to boil it with lime-water, and with the serum of blood; to neutralize some oxalic acid, and

* Hence the reason why in making jellies, if the quantity of sugar is not double that of the juice, it requires so long boiling to evaporate the superfluous water, and the jelly loses its gelatinizing property, or if it does gelatinize it soon spoils.

separate from it many impurities ; and then to evaporate it to a certain consistence, and cast it in a mould, or suffer it to crystallize. The constituent principles of sugar are, oxygen, carbon, and hidrogen.

GLUTEN is an elastic, ductile, seemingly fibrous, or membranous substance, insoluble in water, and putrefiable like animal matter. Its taste is insipid. It is slightly soluble in alcohol. It is dissolved by alcalies. Dried gently, it becomes semi-transparent, hard, and breaks with a noise and smooth fracture. It may be obtained by working or kneading flour repeatedly with water, the insoluble mass remaining is gluten. It may be obtained from the expressed juice of scurvy-grass, cresses, &c. by merely suffering it to stand exposed to the air, in order to separate the colouring matter, and then boiling it briskly for a few minutes. The gluten will coagulate, and may be separated by percolation. It consists of hidrogen, carbon, and nitrogen ; and differs from the preceding vegetable principles by containing a much larger portion of nitrogen.

FIXED OIL is an immediate principle in many vegetables. It is somewhat thick, mild, inodorous, or slightly odorous. It is inflammable when very hot, or reduced into vapours. It absorbs oxygen from the air, and thickens or becomes concrete. It is insoluble in water, and forms soaps with alcalies. Fixed oils exist rarely except in nutritive seeds or kernels, it is extracted by mechanical pressure, or by trituration in water. Oil of olives, linseed, &c. belong to this class.

VOLATILE OIL is a fluid of a strong aromatic odour, and acrid taste. It is very inflammable, and not easily saponifiable by alcalies. It is volatilized at 212° . It is soluble in alcohol. It dissolves resin and camphor, and is easily inflammable by the affusion of nitrous acid. It is usually obtained by subjecting vegetables to distillation with water ; part of it becomes dissolved by

that fluid, but the greatest part floats on the surface. Oil of lavender, rosemary, &c. are volatile oils obtained in that manner.

CAMPBOR is a white, concrete, crystalline, brittle matter, of a strong pungent taste and odour; highly volatile and inflammable. It is soluble in alcohol, ether, and oils; water takes up a minute quantity. It is soluble in sulphureous, muriatic, or fluoric acid gas. The nitric acid also dissolves it, but the camphor soon separates and floats upon its surface in the form of an oily-like fluid. It is principally extracted from the branches and wood of the *laurus camphora*, a species of laurel, growing in China, Japan, Sumatra, &c. by submitting them to distillation. The camphor thus obtained, is afterwards purified in this, and other countries, by re-subliming it. It exists in small quantities in thyme, rosemary, sage, and many other labiated plants; it may be extracted by distilling these plants, and exposing their oil to the air at a temperature between 22° and 54° . The oil gradually evaporates, and the camphor is left behind in a crystalline state. It consists of hidrogen and charcoal.

WAX. The obvious qualities of wax are well known. It is insoluble in water and in alcohol, but soluble in volatile and fixed oils. Alcalies form with it a soap. It is very fusible, and inflammable at a high temperature. Wax is formed on the antherae of flowers, whence it is collected by the bee. It is likewise found upon the upper surface of the leaves and fruits of many trees.

RESIN is either in the concrete or fluid state, it is soluble in alcohol, ether, or oils, but not in water. It melts at a heat not exceeding that of boiling water. Heated strongly it burns. It possesses a certain degree of transparency. Its colour is in general between yellow and brown. Resin frequently exudes spontaneously from plants, or flows out when they are wounded for that purpose. Sandarach, mastich, turpentine, &c. are resins.

EXTRACT exists abundantly in the juice of all plants; it is soluble in water, in alcohol, and in diluted acids; but insoluble in ether. It has a strong affinity for alumine. Exposed to air it gradually absorbs oxygen, and then loses its solubility in water. The same effect is produced by oxygenated muriatic acid. It is obtained by mechanical pressure; by the simple infusion of the plant in a liquid; or by its decoction in water, and subsequent evaporation. Its component principles are carbon, hydrogen, nitrogen and oxygen. Opium, liquorice juice, &c. are extracts.

CAOUTCHOUC, or ELASTIC GUM, is a concrescible juice, remarkable for the great elasticity which it acquires when dry. It can be stretched to a considerable extent without breaking, and immediately contracts again when the force is withdrawn. It is soluble in ether and volatile oils. When exposed to heat it melts and burns with a bright flame. It is principally obtained by puncturing certain trees of South America, namely, the *haevea caoutchouc*, and the *jatropha elastica*. It is first thick and milky, and becomes concrete on being exposed to the air. The blackish colour of the Indian rubber of commerce is owing to the method of drying it. It exists also in the missletoe, in gum mastich, and in various plants.

ACIDS. The acids which exist ready formed in vegetables are the citric, malic, oxalic, gallic, benzoic, tartareous, acetous, and suberic. They have been examined already under their respective heads.

TANIN is obtained in the form of a dry powder. Its taste is very astringent. It is soluble in water and in alcohol: the solution, when concentrated, feels unctuous to the touch, and froths, when agitated, like a solution of soap. Its principal property is that of forming an insoluble compound with animal jelly. On this property is founded the art of tanning. Tanin may be ob-

tained, according to Proust, by mingling a decoction of galls with a solution of muriate of tin. An insoluble compound is formed, consisting of oxid of tin and tanin. This precipitate, after being washed, is to be dissolved in water, and a current of sulphurated hydrogen gas passed through it; this combines with the oxid of tin, and the tanin is left in the solution.

COLOURING MATTER exists in vegetables, combined with various other principles, and alters its properties according to the nature of the substances with which it is united. It has a strong affinity for alumine and oxid of tin, in consequence of which their solutions precipitate infusions of colouring principle in water. Colouring matter is extracted from vegetable substances by water, alcohol, or oils; *viz.* from Brazil wood, logwood, alkanet root, &c.

On the extraction and fixation of colouring matter depends the formation of vegetable pigments or lakes, and the whole art of dying.

SUBER, or CORK, is a substance well known. It is the outer bark of the *quercus ruber*. It burns with a bright flame. Nitric acid converts it into a peculiar acid, called the suberic acid. Fourcroy supposes that the epidermis of all vegetables is a substance analogous to cork.

WOOD, or LIGNEOUS MATTER, forms the vegetable skeleton or the basis of wood. It consists of a multitude of longitudinal fibres. It is insipid, and insoluble in cold or hot water. It is somewhat transparent. It is combustible. When gradually heated, if air be excluded, it blackens, and becomes converted into charcoal, which retains exactly the form of the original mass. It may be exhibited pure, by boiling shavings of wood repeatedly in water and alcohol, to extract from it all the substances soluble in these fluids.

SPONTANEOUS CHANGES OF VEGETABLE MATTERS.

Having considered those immediate principles of vegetables, which constitute the body of the plant and which are discoverable by simple processes ; we shall now examine the spontaneous changes they undergo from the re-action of their parts upon each other under certain circumstances.

It is well known that all organized substances, when dead, suffer certain changes, if placed in a certain temperature, and in contact with air and water. Our present task however is to consider only such changes as should be examined by the chemical philosopher, on account of the light they throw upon many of the phenomena of nature and art ; we shall therefore begin with the theory of fermentation, of which three kinds are distinguished, the vinous, acetous, and putrefactive, characterised principally from each other by the nature of their products.

1. VINOUS FERMENTATION.

Before we consider this species of fermentation we must premise, that by the term fermentation in general, is understood a spontaneous motion which is excited in vegetable or other organized substances, and which totally changes their properties. The conditions necessary for that purpose are, a certain degree of fluidity, a certain degree of heat, and access of air.

All vegetable substances, containing saccharine matter, are susceptible of the vinous fermentation. When any sweet vegetable juice or other saccharine matter is suffered to be exposed undisturbed to a temperature between 60° and 80° F. it first becomes turbid and viscid ; an intestine motion and increase of bulk gradually takes place ; air bubbles are discharged from its whole mass, bursting forth with a perceivable noise, and forming a kind of froth or *yeast* ; the sweetness of the fluid disappears, and a pungent taste is acquired. After a certain time these phenomena

cease, the fluid deposits a copious sediment, and becomes again clear, bright, and transparent. It has then acquired a brisk taste, a vinous odour, and an intoxicating power.

WINE.

Wine is the product of fermentation, obtained, under similar circumstances, from the expressed juice of the grape. The grapes are put into a vessel, exposed to a temperature of about 50° F. bruised and much agitated; after which the fermentation is excited, and the appearances before mentioned take place. When the fermentation ceases the wine is drawn off from the lees into casks, where it undergoes a second, though insensible fermentation, which more intimately develops its principles; and it is this change which causes the difference between *old* and *new wine*. Wine is more spirituous and intoxicating as the quantity of saccharine matter contained in the juice of the grape is greater. By processes similar to this, raisin, gooseberry, and other wines; cyder, and perry, may be obtained.

BEER.

Porter is made in this country from barley in the following manner: barley is first reduced to malt, by being steeped in water; it is then drawn off, and the barley is spread upon a floor about 6 inches thick, where it begins to germinate. The germination is suffered to continue till the radicle is $\frac{2}{3}$ or $\frac{3}{4}$ of the length of the grain. As soon as this is accomplished, the grain is spread thinner, and turned over twice a day, for several days; it is then transferred to the kiln heated with *wood*, and dried highly, or till it acquires a brown colour, it is then called *brown malt*.* From this malt, porter is brewed in the following manner:

A quantity of malt, freed from its germ, is coarsely ground and put into a vessel, called the mash-tub. Hot water, under the degree of boiling, (of about 160° or 180° F.) is poured on it, and the

* Malt very gently dried by means of *coke* for making ale is called *pale malt*.

whole is stirred intimately together, either by machinery † or by the hand of man; by this means the soluble part of the malt is extracted. When this operation is over, the liquor, called the *extract*, is drawn off. Another infusion is then made by means of water of a higher temperature, which of course is weaker than the former, and these are either mixt or kept separate. Both have a sweet taste, they contain the saccharine, the extractive, and the gelatinous parts of the grain. The infusion thus obtained is called *wort*. It is then boiled with hops to give it a certain aromatic bitterness, and to render it less liable to be spoiled in keeping; and is cooled as expeditiously as possible in very large shallow vessels called *coolers*, in which it measures no more than from 1 to 2 inches. As soon as it is cold it is transferred into the *fermenting-tub*, a certain quantity of yeast is added, and the whole is suffered to ferment. When the fermentation has advanced to a due degree, and the yeast ceases to rise, the beer is divided into smaller casks, to facilitate the separation of the yeast; and, lastly, it is conveyed into barrels, and kept in cool places, with the precaution of supplying the loss it suffers by evaporation. Eight bushels of malt, and 10 lb. of hops produce upon an average 100 gallons of London porter.

ALCOHOL, OR ARDENT SPIRIT.

If wine or beer be distilled, a colourless fluid passes over into the receiver of a strong heating taste, a penetrating odour, and an intoxicating property. This fluid is called ardent spirit. It is capable of being inflamed without a wick, and burns without smoke, and with a flame which is blue at the edges and white in the middle. It is very volatile, and consequently evaporates spontaneously at common temperatures. It is miscible with water and alcalies. It dissolves resins, sugar, essential oils,

Y 3

† The first mechanical contrivance of this kind was invented by Edward Biley, Esq. a scientific brewer, to whom I am indebted for this account of brewing porter.

camphor, &c. It is decomposed by most of the dense acids: the result is a very odorous, pungent, inflammable, and highly volatile fluid, called *ether*.

To prepare *sulphuric ether*, any quantity of sulphuric acid is gradually mingled with an equal weight of alcohol in a retort; heat is then applied by a sand-bath, the retort being connected with a receiver kept cool by water; a colourless fluid condenses in the receiver. When the distilled liquor amounts to about half the quantity of alcohol employed, or when the neck of the retort becomes obscured with white fumes, the distillation is to be stopped; a thick black fluid remains in the retort. The distilled liquor, which is the ether, impure from the admixture of water and sulphureous acid, is to be mixed with a small quantity of potash, and subjected to distillation by a very gentle heat. It is thus obtained nearly pure.

RATIONALE... The theory of the formation of ether is far from being accurately ascertained. According to the explanation which, till lately, was generally received, in the formation of sulphuric ether, the alcohol is decomposed by part of its hydrogen attracting part of the oxygen of the sulphuric acid: the balance of attractions existing between the principles of the alcohol being thus broken, a large quantity of carbon is precipitated, and the remaining elements of the alcohol combine, and form the ether.

Nitric ether may be obtained in the following manner: Two parts of alcohol are poured into a strong glass-bottle, provided with a ground stopper, and placed in a frigorific mixture, or in snow mingled with ice broken small, and in this situation the alcohol is suffered to cool some degrees below the freezing point. One part and a half of nitrous acid are then successively affused, yet by drops only, and at sufficiently long intervals, for fear of the mixture being heated, which, as likewise every agitation, ought to be most cautiously avoided. When the mixture is completed, the glass is for some time left standing quiet in the cold, and well stopped. The ether is, after this, found swim-

ming on the surface, from which it is carefully taken off by means of a separatory funnel, and cautiously rectified upon a little potash or lime.

RATIONALE...The theory of the formation of nitric ether is not less obscure than that of the production of sulphuric ether. It has been ascertained by the experiments of Bayen, that the acid is either decomposed, or combined in such a manner that it is not discoverable by an alkali: he found that the mixture of the acid and alcohol, after being digested for some time, required only the ninth part of the quantity of potash for its saturation, which the quantity of acid employed would have done. The alcohol is also partially decomposed, as oxalic and acetous acids are formed. No carbon, however, is precipitated in a sensible form. It may be said, perhaps, that in this process, part of the carbon, hydrogen, and oxygen of the alcohol enter into new combinations, forming the acetous and oxalic acids; and that the remaining quantites of these elements combine with part of the acid to form the nitric ether.

Acetic and phosphoric ether may be obtained by distilling equal parts of the most concentrated acids of these kinds with alcohol, and proceeding as directed before. No good method of obtaining *muratic ether* is hitherto known, the methods directed do not furnish a fluid which possesses all the properties of ether.

2. ACETOUS FERMENTATION.

If wine or any other vinous fluid be exposed to a heat, from 75° to 85° F. and air be admitted, the properties of the fluid are altered remarkably, it loses its taste and odour, it becomes sour, and turns into vinegar. During this change the fluid is rendered turbid, its surface becomes covered with a mouldy pellicle, a quantity of fibrous matter separates, and forms a kind of skin, which sinks to the bottom, vulgarly called *mother of vinegar*.

VINEGAR.

The most usual method of making vinegar is by means of two vessels, each containing some refuse of grapes, or such matters; one of these is filled with wine, the other is half filled. In this latter the fermentation first begins, at which time it must be checked by filling this vessel out of the other. Soon after the fermentation takes place in the second vessel, which is to be re-filled in turn; and so the process goes on alternately for some weeks, until the vinegar is made.

Vinegar may also be prepared from water, containing about three pounds of raisins or sugar to the gallon: or from the fæces or dregs of apples, pears, &c. from which the juice has been expressed.

Vinegar fully fermented is clear and nearly colourless, it has a pleasant pungent odour, and a sour taste. It possesses all the properties of an acid. When freed from its mucilage, and other heterogeneous admixtures by distillation, it constitutes acetous acid, (page 302.)

3. PUTREFACTIVE FERMENTATION.

When the spontaneous decomposition of vegetable substances is suffered to proceed beyond the production of the acetous acid, the vinegar gradually becomes viscid and foul; air is emitted with a fetid odour; an earthy sediment is deposited; and when the whole process is finished scarcely any thing remains but the salts, the charcoal, and the earths which formed the constituent parts of the vegetable: the fluid, if any is left, is water and acetous acid. This decomposition is called putrefactive fermentation: its properties are more striking in animal matter.

CHEMISTRY OF ANIMAL SUBSTANCES.

GENERAL

EXAMINATION

OF

ANIMAL SUBSTANCES.

ANIMAL substances are far more complicated in their composition than vegetables. Their principal base is hydrogen, combined with a large portion of nitrogen, charcoal, oxygen, phosphorus, and not unfrequently sulphur.

The different substances which constitute the body of animals, are the following,

BONES of animals contain much phosphate of lime and carbonate of lime, deposited in a gelatinous net-work. They are soluble in all the dense acids which reduce the gelatinous net-work to the naked state; it may then be dissolved by boiling water. Mr. Hatchett has found that the bones of quadrupeds and fishes contain also sulphate of lime.

MUSCLES are the principal fleshy parts connected with the bones. They are chiefly composed of fibrin, albumen, gelatine, extract, phosphate of soda, phosphate of ammonia, phosphate of lime, and carbonate of lime.

MEMBRANES are thin, semi-transparent, soft, and pliable bodies, which wrap up or form the external covering of the muscles, bones, viscera, and other parts of the body. Mr. Hatchett has proved that they are destitute of phosphate of lime and saline matters, and that they are principally composed of coagulated albumen.

LIGAMENTS are those strong fibrous and elastic substances which connect the bones with each other; they have been little examined; they yield a quantity of gelatine, by boiling, but by far the greatest part remains unaltered.

TENDONS, commonly called *sinews*, are strong pearl coloured bodies which connect the muscles with the bones. By long and strong ebullition they are dissolved into a nutritious gelatinous mass.

THE SKIN envelopes the whole surface of animals. It is composed of three parts, namely, the *epidermis*, or *cuticle*, the *mucous membrane*, and the *cutis*, or true skin. The epidermis is an elastic membrane; it is that part of the skin which is raised in blisters. It is principally composed of albumen, gelatine, and phosphate of lime. The mucous membrane which is situated immediately under the epidermis, is composed of a soft gelatinous substance which gives to the skin its peculiar colour. The true skin, or cutis, is a thick, firm, elastic membrane, composed of a number of fibres interwoven with each other. Both this and the former are composed of gelatine, fibrin, albumen, and phosphate of lime.

FAT, TALLOW, and MARROW, are of an oleaginous nature, greatly resembling vegetable expressed oil. They may be considered as highly oxygenated oil, containing sebacic acid, and phosphate of lime.

NAILS of animals, Mr. Hatchett has shown, are chiefly composed of a membranous substance, resembling coagulated albumen.

HORNS and HOOFS of animals greatly resemble the former in all their properties.

HAIR, according to Bertholet, yielded carbonate of ammonia, charcoal, nitrogen, and sulphur.

FEATHERS yield nearly the same products as hair. Mr. Hatchett has proved that the quill is chiefly composed of coagulated albumen.

SHELLS, or the crustaceous coverings of certain animals, such as echini, lobsters, crabs, cray-fish, &c. and also the shells of eggs greatly resemble bones in their composition, but the proportion of the carbonate of lime they contain far exceeds that of the phosphate. Mother of pearl is composed, according to Hatchett, of carbonate of lime and membrane. Fish scales are composed of membrane and phosphate of lime.

BLOOD is concremental by repose and cold, and coagulable by heat. It separates into two different parts by rest. The cause of this spontaneous separation is unknown. The white part is called the *serum*, the other coloured part is denominated the *crassamentum*, or *clot*. The serum consists of albumen, gelatine, carbonate, muriate, and phosphate of soda, phosphate of lime, and sulphur. The crassamentum contains albumen, soda and subphosphate of iron. When blood, the moment it is drawn from an animal, is strongly agitated with a stick or other substance, a white, solid, elastic matter separates, called *fibrin*, or animal gluten. It contains more nitrogen than any of the former parts of the blood.

MILK separates spontaneously into three parts, namely, *cream*, *curd*, and *whey*. The first is a butyraceous oil, the second a caseous albumen, and the third a saccharine lymph. Milk is a compound of water, oil, albumen, gelatine, sugar of milk, muriate of soda, sulphur, phosphate of lime, and muriate of potash.

SALIVA, which is secreted by the glands in the mouth, consists of mucilage, albumen, muriate of soda, phosphate of soda, phosphate of lime, and phosphate of ammonia.

TEARS consist, according to Vauquelin, of water, mucilage, soda, muriate of soda, phosphate of lime, and phosphate of soda.

MUCUS OF THE NOSE is analogous to the latter acid. It contains more coagulable mucilage. Its great viscosity is owing to the absorption of oxygen, on being longer exposed to the air than tears.

BILE is a fluid secreted by the liver from the venous blood. It is composed of water, resinous matter, albumen, soda, phosphate of soda, phosphate of lime, muriate of soda, saccharine salt, iron, and sulphurated hydrogen.

BILIARY CALCULI, OR GALL-STONES, are concrete bodies deposited in the gall-bladder, and biliary duct. They are inflammable, very fusible by heat, partly soluble in alcalies, alcohol, or oils. They contain a bitter resinous matter, benzoic acid, lime, soda, and ammoniacal salts. They vary remarkably in their external properties and chemical composition.

URINE of healthy persons always contains phosphoric acid, phosphate of lime, phosphate of magnesia, carbonic acid, carbonate of lime, uric acid, benzoic acid, gelatine, albumen, urea, (or a substance in which the colour and odour of urine principally resides,) resin, muriate of soda, phosphate of soda, phosphate of ammonia, muriate of ammonia, and sulphur.

URINARY CALCULI are frequently composed of uric acid, united to ammonia; others consist of phosphoric acid, combined with ammonia and magnesia.

WAX OF THE EAR is composed, according to Vauquelin, of albumen, soda, phosphate of lime, a colouring matter, and a bitter oil.

TRACHEAL HUMOURS, or MUCUS, which lubricates the trachea and the bronchia; the ocular humours, the humours of the alimentary canal, and other cavities of the body have not been examined with attention. Fourcroy has ascertained that the fæces are always acid, and strongly reddens vegetable blue.

SINOVIA, or the peculiar viscid semi-transparent fluid, found within the capsular ligaments of the different joints of animals, Marqueron and Hatchett found to be composed of fibrous matter, albumen, soda, muriate of soda, phosphate of lime, and water.

SEMINAL FLUID consists of water, mucilage, phosphate of lime, and soda. The semen of other animals has not been analyzed.

LIQUOR OF THE AMNIOS, which surrounds the foetus in the uterus in every part, contains, in women, water, muriate and carbonate of soda, phosphate of lime, and albumen. In the cow, an extractive animal matter, sulphate of soda, and a peculiar crystallizable acid, called *amniotic acid*.

CEREBRAL PULP has been examined by Fourcroy. The pulpy matter of which it chiefly consists, approaches most nearly in its properties to albumen, which is mixed with a saline fluid, consisting of phosphate of lime, soda, and ammonia.

350 SPONTANEOUS DECOMPOSITION OF ANIMAL MATTER.

PERSPIRABLE MATTER has not been accurately analyzed. It seems to be principally water holding in solution a small quantity of lymph and carbonic acid.

HUMOUR OF THE PROSTATA has not been examined. It appears to be albuminous, and of the same nature as all the white humours.

CHYLE, AND THE PANCREATIC AND GASTRIC JUICES have not yet been analyzed with accuracy.

INTESTINAL GAS is composed ordinarily of many gases; principally of carbonic acid, nitrogen, carbonated and sulphurated hydrogen. The first is the ordinary product of a good digestion; the last are the sign and result of a troubled, slow, or irregular digestion.

SPONTANEOUS DECOMPOSITION OF ANIMAL MATTER.

The spontaneous decomposition which animal matter suffers, is called *putrefaction*. The conditions necessary are, a certain degree of moisture, a certain temperature, and a free access of air. The phenomena which attend putrefaction are the following: The colour of the substance first becomes paler, and its texture soft; it acquires an intolerable fetid odour, and its organization is destroyed. The substance encreases in bulk, air bubbles are disengaged, and the whole becomes gradually converted into a greenish black matter of a pulpy consistence; and lastly fluid: a phosphorescent light is frequently observable. In this state it remains for some time, sending forth a horrible offensive odour. This odour gradually disappears, the soft substance acquires more and more consistence, and becomes at last converted into a dry friable powder, resembling a mixture of earths.

It is obvious, that during this process all the principles, which form the organized animal matter, act upon each other according to certain laws; the precise nature of which has not been hitherto accurately ascertained. The gases which are developed, and which fill the cavities and cellular texture, so as to inflate and puff up the body, are evidently ammonia, formed by the union of the nitrogen and hydrogen of the animal matter; and afterwards phosphorated hydrogen, sulphurated hydrogen, carbonated hydrogen, and carbonic acid. In some cases nitric acid is formed. The earthy-like residue, which remains after the process of putrefaction has taken place, consists of charcoal, with other earthy and saline matters. Thus it appears that the elements, which formed the organized animal body, unite together, during the process of putrefaction, two and two, and form a new set of binary compounds of a more simple nature, which enter again with other substances, under favourable circumstances into new combinations, and thus serve for the reproduction and support of new organic and inorganic matter.



From the Press of GEORGE HAYDEN,
Russell Court, Covent Garden.

DESCRIPTION OF THE PLATES.

PLATE I.*

A Perspective view of an improved Gazometer. It consists of a cylindrical vessel, made of japanned copper, or iron, *A.* and a glass cylindrical vessel, *B.* The japanned vessel is furnished with two stop-cocks, one of which is fixed at the top, and the other at the bottom, on opposite sides of the vessel. From the upper cock, a tube, *cc.* runs down the outside of the vessel, *A.* and under its bottom, to the cock, *b.* At the centre of the vessel this tube branches upwards through the bottom of the vessel, *A.* and thus a communication is made with the stop-cocks and the glass vessel, *B.* which is suspended in the vessel, *A.* by means of weights and pulleys contained in the bent tube, *aa.* A graduated rod, affixed, by means of a cap, to the vessel, *B.* expresses, by the coincidence of any of its divisions with the aperture, *x.* the capacity of the emerged part of the glass vessel, and therefore measures the quantity of gas contained in it. In using this apparatus, the vessel *A.* is filled with water, up to the aperture of

Z

* Facing the title-page of vol. i.

the tube in the centre of the vessel. The glass vessel, *B.* is then depressed till the coincidence of the Zero point of the graduated rod, *d.* with the aperture, *x.* indicates its total emersion. This being done, a communication is then made between the tube, *c c.* and the apparatus from which the gas proceeds, by opening either of the cocks, and letting the other be shut. The gas, thus introduced, will of course proceed by the tube, *c c.* and enter the vessel, *B.* which, as it becomes filled, will emerge by the pressure of the gas. For breathing or transferring gases from this apparatus, a flexible tube, *e.* may be joined to either of the stop-cocks, and the quantity of gas expended will be measured by the graduated tube, *d.*

PLATE. II. *

Fig. 1... A table furnace, formed of two large black-lead crucibles, *A. B.* The lower one, out of which the bottom is cut, and which is furnished with a grate, is fixed into a circular support of strong sheet iron, *c.* furnished with two handles for the convenience of removing it. This part of the furnace forms the ash-pit, and is furnished with a door. The upper crucible has a hole cut in its bottom, into which is inserted an iron tube, *d.* (of which part is shown in the drawing) forming the chimney of the furnace, which may be elongated occasionally by an additional piece, so as to increase the draft at pleasure. In order to render this furnace less liable to accidents, a strong iron hoop, *e e.* is fastened round each of the crucibles, the lower of which serves to secure the junction of the two crucibles. In the upper and lower part of the furnace is cut a semi-circular opening for the introduction of charcoal or coke, according to the different processes carried on in the furnace; and the pieces of the crucible, thus removed, may serve as doors to the opening. If an iron sand-bath, with a rim, (which is furnished with the furnace) be

* Facing the title page of vol. ii.

placed upon the lower crucible, the fuel of course must be introduced through the lower aperture; and thus those chemical processes may be performed, which do not admit of the direct application of the fire. But if a reverberatory furnace be required for distilling out of earthen ware, or coated glass retorts, or for applying an intense heat to bodies, capable of supporting a naked fire, a retort, crucible, &c. may then be introduced, and an intense heat obtained by feeding the furnace, through the opening in the upper crucible. The intensity of the fire may be regulated by means of the door in the ash-pit.

Fig. 2 represents a self-acting blow-pipe, invented by Mr. Hooke, mathematical instrument maker. *A.* is a hollow sphere for containing highly rectified alcohol, resting upon its shoulder in the ring, *g.* Into the sphere, *A.* a bent tube, *b.* is screwed for conveying alcohol in the gaseous state to the flame at *o.* This tube is continued within the sphere almost to the top. The globe may therefore be nearly filled. At the top of the sphere there is a safety valve, *c.* to prevent those accidents, which might otherwise arise from the expansion of the fluid, in case the heat applied should be too great. The pressure of this valve may be regulated at pleasure, by the two milled nuts, *e. f.* and carrying the steel arm, *h.* which presses on the valve, *c.* The lamp which heats the alcohol is marked, *k.* It is made to adjust to different distances from the sphere, *A.* by sliding up or down between the two pillars, *l l.* The distance of the flame, *o.* from the jet of the tube, is regulated by the wick-holder of the lamp, being a little removed from the centre of the brass piece, *m.* which is made to screw, and therefore gives to the wick-holder an excentric motion. The opening for filling the globe with alcohol is marked *i.* It is closed by means of a milled finger-button, and collar of leather. *n.* is a mahogany stand supporting the whole.

PLATE. III.

Fig. 1 represents Webster's lamp-furnace, with concentric wicks. It consists of a brass rod, about 2 feet 9 inches high, screwed to a solid brass foot, loaded with lead. On this rod slide three metallic sockets, with straight arms, to which are screwed brass rings of different diameters, for supporting glass retorts, evaporating basons, flasks, crucibles, &c. Each of these rings may, by means of a thumb-screw, be set at different heights. Below these rings is a fountain-lamp, on Argand's plan, which, by means of a thumb-screw, may also be elevated or depressed, in order to communicate more or less heat to the vessel suspended over it. The superior advantage this instrument possesses consists in a second cylinder, added to that of the lamp of Argand. These cylinders are concentric; and by this ingenious contrivance, a double flame and more than double the heat of a common Argand's lamp may be obtained. This lamp-furnace is therefore far preferable to that of Guiton, or any other I am acquainted with.

The construction of the lamp will become more obvious from *fig. 3* and *4. pl. ii.*

Fig. 3, pl. ii. is a section of the concentric cylindrical tubes in which the wicks move. *a a.* and *b b.* are the passages for the wicks.

Fig. 4, of the same plate, represents a view of the wick-frame of the lamp and its adjustment. *a.* represents a finger-button, to which is fixed the rod and notched wheel, *b b.* *c c.* is a brass screw, to which is also fixed a similar wheel, *f.* *d.* is a socket, with a female screw, which works on the male screw, *c c.* and carries the wick-frames, *e e.* which move freely up and down the cylindrical passages, *a a.* and *b b.* By the action of the finger-

Fig. 1.

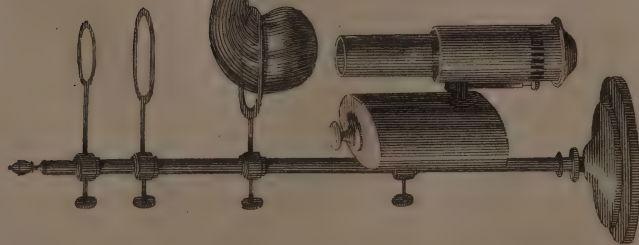
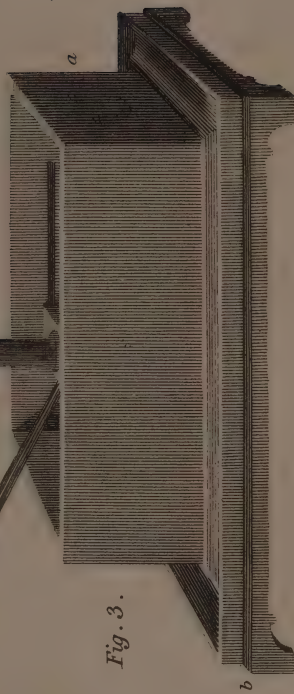


Fig. 2.



Fig. 3.



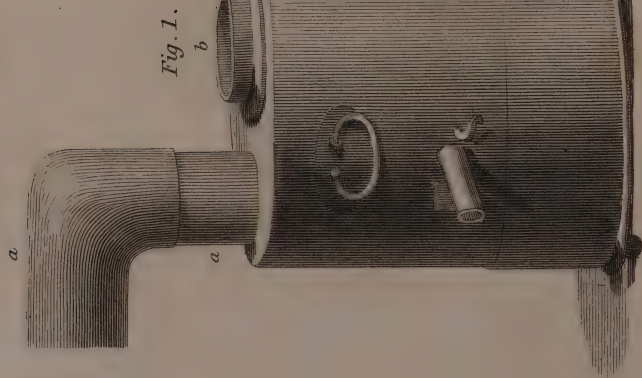


Fig. 2.

Fig. 3.

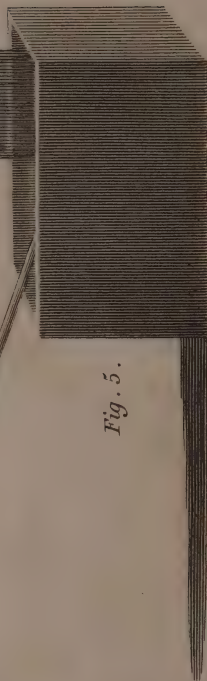


Fig. 4.



button, *a*. on the wheels, *b f.* the screw, *c c.* is put in motion, and, by its effect on the female screw, *d.* adjusts the wick to any required height.

Fig. 2, pl. iii, is a detonating or eudiometer tube of glass. Its bore is about half an inch, and its height 18. It is graduated into cubic inches, and sub-divided into decimal parts. By means of the two conductors, *a a.* a quantity of gas, confined in the tube by water or mercury, may easily be enflamed by the electric spark. Hence this tube is extremely convenient for showing the production of water, nitrous acid, or to expose a confined quantity of gas to an intense heat.

Fig. 3, the same plate, is an improved pneumatic mercurial trough, or tub. It consists of a mahogany box, of greater or less size, standing in a tray made of the same wood. The principal parts of this apparatus are the shelf of the trough and the bottom. The reservoir, properly so called, is the interval between these two planes. The advantage of this apparatus consists in having a broad shelf, fixed on one of the sides of the trough, and a sliding shelf, with a hole in the centre, which communicates with a funnel-shaped opening on the side of the large shelf. Vessels placed on the sliding shelf, may be conveniently filled with gas, by directing the conveying tube of a gas-bottle, or the neck of a retort, into this excavation, and then sliding it on the large shelf of the apparatus; which, from being on one side of the trough, enables the operator to perform his experiments with a less quantity of mercury, and in an easier manner, than in the troughs of the usual construction.

The tray, *b.* is useful for collecting the mercury which may be spilt.

PLATE. IV.

Fig. 1 is a perspective view of a portable universal furnace. It is made of strong wrought iron plates, and lined with fire-

bricks laid in fire-proof loam. The body of the furnace is elliptical, its inner cavity however is in the figure of a cylinder. The height of this furnace without its chimney, *a a*. is two feet. The inner diameter of the cylindrical fire place measures nine inches. It is moveable upon castors. In the upper part of this furnace an iron sand-bath, *b*. is placed, which may occasionally be exchanged for a circular plate, and in that case the upper opening will serve for the introduction of the fuel. There are three openings in the front of this furnace, furnished with sliding plates, which move up and down, or backwards and forwards, and serve as doors. The lower opening, *c*. is the ash-hole of the furnace. In either of the upper openings a muffle may be introduced for the process of cupelation, or an iron retort, &c. (as shown in the drawing) may be inserted for the production of gases, which require high temperatures. In the side of the furnace a hole is cut, furnished with a stopper and door: by means of this opening a tube may be placed across the furnace for exposing different gaseous or other fluids to high temperatures.

From what has been stated already it becomes obvious that *this furnace is calculated for all chemical operations whatever, which require the aid of heat.*

Fig. 2 represents Dr. Gruber's conducting tubes. It consists of two metallic tubes joined to a metallic box consisting of two pieces, sliding in and over each other, made air tight by grinding. The one end of the tube (in the drawing) is joined to the retort placed in the furnace, the extremity of the other tube is extended into the pneumatic trough. The tubes may be elongated by additional pieces to any length required.

Fig. 3 is a bell-glass, having a neck furnished with a brass cap, into which is screwed a stop-cock for transferring gases into flasks, bladders, &c. *a* is a small brass connecting piece, with two female screws, by means of which another stop-cock, fixed to a flask or bladder, may be connected with the stop-cock of the receiver.

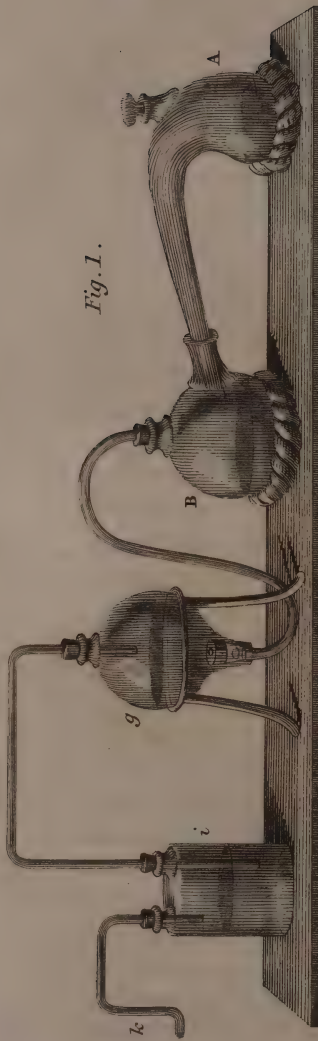


Fig. 1.

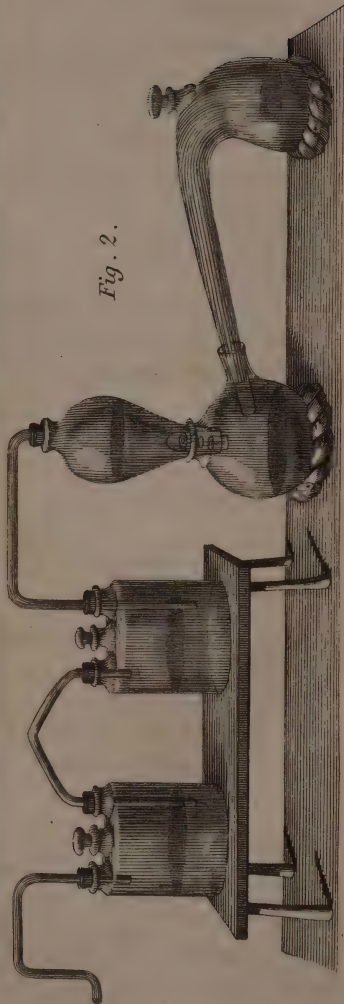


Fig. 2.

Fig. 4 is a flask for weighing gases. Its orifice is furnished with a brass cap and stop-cock. The flask is connected with a bell-glass in the manner stated before. If this flask has been previously exhausted by means of an exhausting syringe, and a communication be then made with the bell-glass by opening both cocks, the gas contained in the bell-glass may be transferred into the flask, by pressing down the bell-glass into the water of the pneumatic trough; the gas will then be forced up into the flask, the cocks being then shut, the flask may be removed, and its weight ascertained by means of a delicate ballance. The difference between the weights of the flask when exhausted, and when filled, give the weight of the gas in the flask, which may, by the same method, be compared to that of common air, &c.

In a similar manner a bladder may be filled with gas by tying its mouth to a stop-cock, and screwing it on that of the bell-glass, by means of the connecting piece, and proceeding as just described.

Fig. 5 is a perspective view of a pneumatic cistern of which a description has been given already, page 178, vol. i.

PLATE. V.

Represents Burkitt's, and Pepys's distillatory apparatus for impregnating fluids with gases, &c.

Fig. 1...*A.* is a tubulated retort, joined to a tubulated receiver, *B.* From this a bent tube proceeds to the bottom of a second receiver, *g.* from the upper tubulature of which a communication is made, by means of a tube twice bent at right angles, with the two necked bottle, *i.* The principal advantage of this apparatus consists in a valve, constructed by placing a plano-convex lens upon the mouth of the small tube, accurately fitted by grinding, and inserted into the lower aperture of the receiver, *g.* and similar to the valve in the well known apparatus of Nooth, but with more

water way. From this it becomes obvious that the gas disengaged from the retort, and not absorbed by the fluid contained in the receiver, B. will by its upward pressure raise the valve, and pass into the receiver, g. without allowing the fluid in that vessel to return into the receiver, B. even when a partial *vacuum* takes place in it. The gas which is not absorbed in the vessel, g. passes into the bottle, i. and if any part of the gas should escape absorption by the fluid in that vessel, it may be conducted into another bottle, or into the pneumatic trough, by means of the tube, k. In this manner, by a continued series of bottles, and tubes, the whole of the disengaged gas may be absorbed.

Fig. 2 is a similar apparatus, invented by Pepys, differing from the former, only by the vessel which contains the valve, being placed *upon* the first receiver: it therefore needs no description.

CORRECTIONS.

VOL. I.

Page 8, line 33, for *to* read *for*.

Page 99, line 14, for *Experiment I.* read *Experiment II.*

Experiment II. read *Experiment III.*

VOL. II.

Page 31, line 21, for *oxid of titanium*, read *oxid of uranium*.

Page 38, line 27, for *ore of borax* read *one of borax*.

I N D E X.

The Roman figures denote the volume, the Arabic show the page.

ACIDS, Formation of	Vol. II.	Page
Division and nomenclature of	...	260
General properties of	...	---
Acid, Acetic	...	303
Acetous	...	301
Amniotic	...	329
Arsenic	...	290
Arsenious	...	292
Benzoic	...	315
Bombic	...	328
Boracic	...	265
Carbonic	...	289
Camphoric	...	317
Citric	...	308
Columbic	...	300
Chromic	...	298
Fluoric	...	267
Gallic	...	312
Laccic	...	327
Lactic	...	325
Malic	...	310
Molybdic	...	296
Mucous	...	318

	Vol.	Page
Acid, Muriatic	II.	262
Oxygenated		296
Nitric		285
Nitro-muriatic		272
Nitrous		288
Oxalic		304
Phosphoric		278
Phosphorous		281
Prussic		320
Saccho-lactic		318
Sebacic		326
Succinic		314
Suberic		319
Sulphuric		273
Sulphureous		275
Tartareous		330
Tungstic		294
Uric		321
Acetites		302
Acetite of Potash		—
Soda		—
Barytes		—
Strontia		—
Lime		—
Magnesia		—
Silver		—
Mercury		—
Iron		—
Lead		—
Zinc		—
Nickel		—
Action, chemical	I.	16
Instances and nature of		17
Affinity, chemical		37
Theory of		—

INDEX.

iii

	Vol.	Page
Affinity, chemical, Nature of	I.	37
Instances of		39
Laws of		49
Agate	II.	188
Air, atmospheric	I.	213
Production of artificial		211
Mechanical examination of		214
Chemical examination of		221
Methods of ascertaining its purity		225
Analysis of		222
Decomposition of		282
Aigue-marine	II.	204
Agustine		214
Ammonia, carbonate, conversion of into gas	I.	91
Alcalies	II.	220
Enumeration of		221
General properties of		—
Alcaline Soaps	I.	240
Alcohol		341
Alloy which melts in boiling water		46
Alumine	II.	197
Aqua regia		272
Amber		314
Analysis of ores of Arsenic		11
Antimony		67
Bismuth		55
Cobalt		38
Copper		141
Chrome		21
Columbium		24
Gold		174
Iron		131
Lead		114
Manganese		50

	Vol.	Page
Analysis of ores of Mercury	II.	85
Molybdena		19
Nickel		42
Silver		155
Tellurium		70
Tin		106
Titanium		28
Tungsten		16
Uranium		31
Zinc		92
Antimony		56
Hydrogenated, hidro-sulphuret of		62
Hydrogenated, sulphurated oxid of		94
Annealing of glass		194
Ammonia	I.	309
Decomposition of		814
Liquid		312
Arbor Dianæ	II.	151
Apparatus pneumatic	I.	178
Burkitt's,	II.	359
Pepys's		360
Arsenic		6
Combustion of, in oxigen gas	I.	193
Nature	II.	6
Testaceous		—
Sulphurized		—
Arseniates		291
Arseniate of Soda		—
Potash		—
Ammonia		—
Magnesia		—
Lime		—
Mercury		—
Silver		—

INDEX.

v

				Vol.	Page
Arseniate of Nickel	...	...	...	II.	291
Lead	...	...	...	—	—
Copper	...	...	...	—	—
Aurum musivum	...	...	...		98
Graphicum	...	...	...		68
Paradoxum	...	...	...		—
Ascension, spontaneous, of fluids in glass tubes	...		...	I.	23
Accension, spontaneous, of metals in oxygenated muriatic acid gas	...	...	...		338
Attraction	...	...	...		16
Axiom of	...	...	...		21
Instances of	...	...	...		21
Corpuscular	...	...	...		32
Theory of	...	...	...	—	—
Instances of	...	...	...		33
General laws of	...	...	...		34
Measurement of	...	...	...		34
Azotic gas	...	...	...		207
BARYTES	...	...	...	II.	222
Beer	...	...	...	II.	340
Bismuth	...	...	...		51
Bile	...	...	...		348
Biliary calculi	...	...	...	—	—
Bodies nature of simple	...	...	...	I.	13
Fusible and infusible	...	...	...		85
Corpuscular, theory of	...	...	...		11
Classification of simple	...	...	...		12
Balloons, theory of	...	...	...		201
Baldwin's phosphorus	...	...	...		130
Baikalite	...	...	...	II.	216
Baro-Selenite	...	...	...		222
Bell-metal	...	...	...		139
Benzoates	...	...	...		316
Benzoate of ammonia	...	...	...	—	—

				Vol.	Page
Benzoate of Alumine	...	...	...	II.	316
Barytes	...	...	...	—	—
Lime	...	...	...	—	—
Potash	...	...	...	—	—
Soda	...	...	...	—	—
Berril	...	...	...	...	214
Borates	...	...	...	...	266
Borate of Soda	...	...	...	—	—
Ammonia	...	...	...	—	—
Lime	...	...	...	—	—
Magnesia	...	...	...	—	—
Alumine	...	...	...	—	—
Silver	...	...	...	—	—
Mercury	...	...	...	—	—
Copper	...	...	...	—	—
Iron	...	...	...	—	—
Lead	...	...	...	—	—
Nickel	...	...	...	—	—
Zinc	...	...	...	—	—
Borax	...	...	...	...	265
Boracite	...	...	...	...	215
Bones	...	...	...	...	345
Bologna Phosphorus	...	...	...	...	129
Phial	...	...	...	...	195
Bonnet-cane	...	...	...	I.	133
Bodies, nature of simple ones	...	...	...	...	13
Brimstone	...	...	...	...	140
Bleaching of linen	...	...	...	...	333
Blende	...	...	...	II.	80
Blood	...	...	...	...	347
Blood-stone	...	...	...	...	117
Blow-pipe, self-acting	...	...	...	...	355
Blue, mountain	...	...	...	...	132
Brass	...	...	...	...	138
Brain	...	...	...	...	349

	Vol	Page
CALOMEL	II.	79
Calamine		86
Calciform, silver ore		144
Calculi, biliary		318
Urinary		349
Camelion, mineral		49
Candle, philosophical	I.	202
Caloric		61
Theories of		62
Equilibrium of		—
Whether the same with light		—
Temperature of		—
Latent		86
Comparative quantity of in different bodies		105
Radiant		101
Invisible rays of		103
Reflection of		102
Velocity of the rays of		101
Methods of collecting		—
Camphor	II.	336
Caoutchouc		337
Camphorates		317
Camphorate of Alumine		—
Ammonia		—
Lime		—
Potash		—
Soda		—
Capacity for caloric, explanation of	I.	98
Clay, potters	II.	197
Cassius, purple precipitate		165
Carbon, pure	I.	166
Gazeous oxid of		255
Carbonates		283
Carbonate of Ammonia	II.	284
Soda		—

	Vol.	Page
Carbonate of Potash	II.	284
Magnesia	—
Silver	—
Mercury	—
Copper	—
Iron	—
Tin	—
Lead	—
Nickel	—
Zinc	—
Carbonic acid gas	I.	234
Carbonated hydrogen gas, heavy	249
light	243
Cast Iron	II.	122
Charcoal	I.	169
Champagne, to what its briskness is owing	221
Chalcolite	II.	29
Chemistry, Definition of	I.	1
General nature of	3
Subjects and importance of	—
History of	5
Chemical Action	17
Processes	2
methods of performing	1
Philosophers	10
Chrome	II.	20
Chromic acid	298
Chromates	299
Chromate of Alumine, and iron	20
Lead	299
Iron	298
Chyle	250
Chlorite	217
Calcedony	188
Chlorophane	268

INDEX.

ix

	Vol.	Page
Cinnabar	II.	67
Citric acid		308
Citrates		309
Citrate of Ammonia		—
Barytes		—
Lime		—
Potash		309
Magnesia		—
Strontia		—
Iron		—
Mercury		—
Lead		—
Zinc		—
Combustibles, simple	I.	358
Compound		—
Partial		—
Cobalt	II.	32
Cold, production of extreme degrees of	I.	51
Apparent radiation of		102
Columbium	II.	23
Colours Theory of	I.	116
Colouring matter	II.	338
Combustion, Theories of		349
Lavoisier's		—
Thomson's		—
Supporters of	I.	359
Combination, chemical		—
Conducting power of bodies		79
Copper	II.	132
Native		132
Vitrious ore of		134
Combustion of, in oxygen gas	I.	193
Corrosive muriate of mercury	II.	78
Cork		336
Corundum		197

	Vol.	Page
Cortical layers	II.	331
Cotyledons		332
Crystal		188
Crassamentum		347
Cupellation		175
Crown Glass		194
Detonation	I.	352
Dews		97
Diamond		166
Drops, formation of		25
Prince Rupert's	II.	193
EARTHS,		186
Enumeration of		—
Properties of		187
Elastic-gum		337
Etiolation	I.	118
Ether, spontaneous accension of	II.	349
Conversion of into gas		94
Acetic		342
Nitric		—
Phosphoric		—
Sulphuric		—
Emmerald		204
Enamel, white		97
Eudiometer, Bertholet's	I.	230
Davy's		231
Humbolt's		228
Marti's de		—
Priestley's		223
Scheele's		227
Seguin's		229
Eudiometry		225
General remarks on		232
Extract	II.	337

	Vol.	Page
Expansion by heat	I.	69
of Water		—
FAT	II.	346
Feathers		347
Fecula		334
Fermentation		349
Vinous		—
Fermentation, Acetous		343
Putrefactive		344
Fish-scales		347
Flame of candles	I.	352
A rose-coloured	I.	194
A green		—
A yellow		—
An orange-red		—
Flint	II.	181
Glass		193
Flux, Black		287
White		—
Fluid Seminal		349
Phosphorated	I.	160
A luminous which throws out flashes of light		164
Fluids, three different, which do not mix		18
Blue, become changed into red or green		40
Green, become changed into purple		—
Two which produce a solid		41
Fluids, conversion of into the gaseous state		92
Fluidity not essential to bodies		84
Flowers discous follow the sun in his course		118
Fluor spar		343
Fluoric acid	II.	267
Fluates		268
Fluate of Ammonia		—
Barytes		—
Potash		—

			Vol.	Page
Fluate of Soda	...	...	II.	268
Magnesia	...	...	...	—
Strontia	...	...	...	—
Silex	...	...	...	—
Iron	...	...	...	—
Mercury	...	...	...	—
Tin	...	...	...	—
Silver	...	...	...	—
Fogs	...	...	I.	97
Food of Plants	...	...	II.	332
Freezing mixture	...	...	I.	87
Tables of	...	...	...	88
Fulminating powder	...	...	...	—
Gold	...	...	...	—
Silver, Bertholet's	...	...	II.	149
Chenevix's	...	...	...	150
Mercury	...	...	...	81
Fusion	...	...	...	—
Fusing powder	...	...	...	287
Furs in what their warmth consists	...	...	...	82
Furnace, portable table	...	...	...	354
Universal	...	...	...	357
GALLIC ACID	...	...	...	312
Gallates	...	...	...	313
Galena	...	...	...	107
Gasses	...	...	I.	175
Nature and formation of	...	...	...	—
Classification of	...	...	...	182
Method of collecting	...	...	...	180
Gas Azotic	...	...	...	207
Oxygen	...	...	...	184
Hydrogen	...	...	...	207
Carbonic acid	...	...	...	234
Light carbonated hydrogen	...	...	...	243
Heavy carbonated hydrogen	...	...	...	249

	Vol.	Page
Gas, Olefiant	I.	249
Sulphurated hydrogen		261
Phosphorated hydrogen		270
Phosphorated carbonated hydrogen		348
Nitrous		278
Ammoniacal		309
Sulphureous acid	I.	318
Muriatic acid		327
Oxygenated		333
Fluoric		343
Intestinal	II.	350
Gazeous oxid of carbon		256
Nitrogen		292
Gazometer, Accum's improved		354
Gastric juice		350
Gall		—
Galvanism, method of decomposing water by		—
Geology of the earths	I.	21
Glass, Formation of	II.	192
Flint		193
Crown		193
Bottle		194
Coloured		195
Method of etching on	I.	346
Glazing of pottery	II.	203
Glucine		204
Gluten		335
Gold		159
Fulminating		167
Powder		177
Shell		171
Coin		176
Potable		166
Gum		333
Gun-powder		287

	Vol.	Page
Gun-metal	II.	139
Green, Mountain		132
Scheele's	II.	139
Gypsum		247
Graphite		117
HEAT, Definition of	I.	61
Theories of		62
Nature and theorems of		63
Methods of exciting		65
Measurement		73
Sensible, free or uncombined		63
Specific and absolute		64
Equal distribution of		78
Propagation of		79
Conducting power of		79
Expansive property of		69
Conductors of		—
Production of, by Collision		65
Chemical action		67
Electricity and galvanism		68
Solar rays		67
Radiation of		101
Refrangibility of the rays of		103
Separation of, from solar light by refraction		—
Hematites	II.	117
Hydrogen	I.	138
Hydrogen Gas		193
Light carbonated		—
Heavy carbonated		—
Sulphurated		260
Phosphorated		270
Carbonated phosphorated		348
Horns	II.	347
Hoofs		—
Hair		—

			Vol.	Page
Hydro-sulphuret	...	...	... II.	347
Hydro-sulphuret of potash	...	...	... I.	267
Hydrogenated sulphuret of ammonia	...	...	...	268
JARGON	...	...	... II.	208
Jasper	...	...	...	188
Jade	...	...	... II.	216
Jelly	...	...	...	334
INDIAN RUBBER	...	...	...	337
Ink, sympathetic, Green	...	...	...	36
Blue	...	...	...	36
Inflammation	...	...	... I.	352
Ignis fatuis.	...	...	...	272
Ignition, explanation of	...	...	...	352
Iron	...	...	... II.	116
Crude	...	...	...	118 123
Grey	...	...	...	—
White	...	...	...	—
Malleable	...	...	...	—
Cast	...	...	...	—
Hot short	...	...	...	120
Cold short	...	...	...	—
Method of distinguishing from steel	...	...	...	123
converting into steel	...	...	...	121
Ore, specular	...	...	...	117
Brown oxid of	...	...	...	127
Black, green, and red oxid of	...	...	...	127
Combustion of, in oxygen gas	...	...	...	119
gaseous oxid of nitrogen	...	...	...	306
Method of gilding	...	...	...	127
Ore, magnetical specular	...	...	...	111
Stone, magnetical	...	...	...	177
Ivory, curious method of silvering	...	...	... I.	124
Kupfernickel.	...	...	... II.	39
Lac, white	...	...	...	327
Laccic acid	...	...	...	—

				Vol.	Page
Lactic acid	...	...	...	II.	323
Lactates	...	...	...		—
Latent caloric	...	...	...		—
Lead	...	...	...		107
Ore, red	...	...	...		—
Oxids of	...	...	...		110
Glass of	...	...	...		111
Tree	...	...	...		113
Ligaments	...	...	...		346
Lime	...	...	...		246
Stone	...	...	...		—
Leucite	...	...	...		228
Light, its nature	...	...	...	I.	106
Theorems of	...	...	...		—
Sources of	...	...	...		107
MAGNESIA	...	...	...	II.	216
Manganese	...	...	...		44
Malachite	...	...	...		132
Malic acid	...	...	...		310
Malates	...	...	...		311
Malate of Potash	...	...	...		—
Soda	...	...	...		—
Ammonia	...	...	...		—
Lime	...	...	...		—
Barytes	...	...	...		—
Massicot	...	...	...		110
Matter, colouring	...	...	...		338
Pespirable	...	...	...		350
Marble carara	...	...	...		247
Marrow	...	...	...		346
Malleability	...	...	...		4
Malt	...	...	...		340
Menachanite	...	...	...		26
Metals, enumeration of	...	...	...		2
Metallurgy	...	...	...		4

				Vol.	Page
Membrane	...	...	...	II.	346
Mineralogy	...	...	...		4
Mica, green	...	...	...		29
Milk	...	...	...		348
Mist	...	...	...	I.	97
Mercury	...	...	...	II.	71
Congelation of	...	...	...		82
Fulminating	...	...	...		81
Phosphorated	...	...	...	I.	164
Sulphuret of	...	...	...		39
Molybdena	...	...	...	II.	17
Molybdic acid	...	...	...		296
Molybdates	...	...	...		297
Molybdate of potash	...	...	...		—
Sulphuret of	...	...	...	I.	17
Mundick	...	...	...	II.	—
Muscles	...	...	...		345
Mucous of the nose	...	...	...		346
Mucous acid	...	...	...		318
Mucilage	...	...	...		333
Muriatic acid	...	...	...		262
Gas	...	...	...	I.	327
Muriates	...	...	...	II.	263
Muriate of Ammonia	...	...	...	I.	332
Soda	...	...	...	II.	264
Potash	...	...	...		—
Barytes	...	...	...		—
Strontia	...	...	...		—
Lime	...	...	...		—
Magnesia	...	...	...		—
Iron	...	...	...		—
Tin	...	...	II. 101. and		—
Aresnic	...	...	...		—
Zinc	...	...	II. 91. and		—
Nickel	...	...	...		—

				Vol.	Page
Muriate of Lead	...	...	...	II. 111 and II.	264
Gold	...	...	...	— 164 and	—
Silver	...	...	...	— 149 and	—
Copper	...	...	...	...	—
Bismuth	...	...	...	— 54 and	—
Cobalt	...	...	...	...	36
Platina	...	...	...	...	181
Mercury	...	...	...	...	78
Muriatic acid, oxygenated	...	...	...	...	269
Muriates, oxygenated	...	...	...	...	270
Muriate, oxygenated, of Potash	...	...	...	...	271
	Soda	...	...	...	272
	Lime	...	...	...	—
	Strontia	...	...	...	245
	Copper	...	...	...	272
	Iron	...	...	...	—
	Tin	...	...	...	—
	Lead	...	...	...	—
	Antimony	...	...	...	60
Mortar	...	...	...	...	253
NAILS	...	...	...	...	347
Nickel	...	...	...	...	39
Nitric acid	...	...	...	...	285
Nitrous Acid	...	...	...	...	288
Gas	...	...	...	I.	278
Decomposition of	...	...	...	...	288
Nitro-muriatic acid	...	...	...	II.	272
Nitrates	...	...	...	...	286
Nitrate of Potash	...	...	...	...	287
	Soda	...	...	...	—
	Ammonia	...	...	...	—
	Barytes	...	...	...	—
	Strontia	...	...	...	—
	Magnesia	...	...	...	—
	Silver	...	...	II. 148 and	—

INDEX.

xix

				Vol.	Page
Nitrate of Mercury	...	...	II.	79 and II.	287
Copper	...	...	...	...	—
Nickel	...	...	...	...	—
Lime	...	...	...	...	—
Cobalt	...	...	II.	35 and	—
Iron	...	...	...	...	—
Zircon	...	...	...	...	210
Bismuth	...	...	...	...	53
Zinc	...	...	...	...	91
Nitrites	...	...	...	...	289
Nitrogen	...	...	...	I.	139
Gas	...	...	...	...	207
Gazeous oxid of	...	...	...	...	292
OCHRE, Uranitic	...	...	...	II.	29
Nickel	...	...	...	...	39
Bismuth	...	...	...	...	57
Antimonial	...	...	...	...	56
Oils, fixed	...	...	...	...	335
Volatile	...	...	...	...	—
Olefiant gas	...	...	...	I.	249
Orpiment	...	...	...	II.	16
Oxalic acid	...	...	...	...	304
Oxalates	...	...	...	...	305
Oxalatè of Ammonia	...	...	...	...	—
Potash	...	...	...	...	—
Soda	...	...	...	...	—
Lime	...	...	...	...	—
Strontia	...	...	...	...	—
Barytes	...	...	...	...	—
Operations, chemical	...	...	...	I.	1
Ores	...	...	...	II.	3
of aresnic	...	...	...	...	4
Analysis of	...	...	...	...	11

	Vol.	Page
Ores of Antimony	II.	56
Analysis of		67
Bismuth		51
Analysis of		55
Cobalt		32
Analysis of		38
Copper		133
Analysis of		141
Chrome		20
Analysis of		21
Columbium		23
Analysis of		24
Gold		159
Analysis of		174
Iron		116
Analysis of		131
Lead		107
Analysis of		114
Manganese		44
Analysis of		50
Mercury		71
Analysis of		85
Molybdena		17
Analysis of		19
Nickel		39
Analysis of		42
Silver		143
Analysis of		155
Tellurium		68
Analysis of		70
Tin		94
Analysis of		106
Titanium		26
Analysis of		28

	Vol.	Page
Ores of Tungsten	II.	13
Analysis of		16
Uranium		29
Analysis of		31
Zinc		86
Analysis of		92
Oxids	I.	185
Oxygenation		189
Oxygenated muriatic acid	II.	269
Muriates		270
Oxygen	I.	137
Gas		184
Oxid of Antimony	II.	56
Copper		132
Tin		97
Mercury		80
Manganese		44
Bismuth		51
Tellurium		10
Zinc		29
Pancreatic juice		350
Painting, method of copying on glass	I.	122
Perspirable matter		350
Pechblende	II.	29
Powder of fusion		287
Pneumatic apparatus	I.	178
Potash	II.	239
Silicius		235
Sulphuret		236
Phosphorus	I.	153
Liquid		161
Solar		128
Bologna		129
Phosphoric Fire-bottles		159

			Vol.	Page
Phosphoric Fire-work	...	...	I.	163
Tapers	...	...		160
Phosphorated Ether	...	...		—
Mercury	...	...		164
Hydrogen gas		...		270
Carbonated hydrogen gas		...		—
Phosphorous acid	...	...	II.	281
Phosphites	...	...		282
Phosphite of Potash		...		—
Soda	...	...		—
Ammonia	...	...		—
Lime	...	...		—
Barytes		...		—
Strontia	...	...		—
Magnesia	...	...		—
Alumine		...		—
Phosphoric Acid	...	...		278
Phosphates	...	...		280
Phosphate of Ammonia		...		—
Soda	...	...		—
Potash	...	...		—
Magnesia		...		—
Barytes	...	...		—
Strontia		...		—
Mercury	...	...		—
Copper	...	...		—
Iron	...	...		—
Lead	...	...		—
Bismuth	...	...		—
Tin	...	...		—
Zinc	...	...		—
Phosphuret of Lime	...	...	I.	165
Arsenic		...	II.	71
Cobalt	...	...		35

			Vel.	Page
Phosphuret of Bismuth	...	...	II.	61
Manganese	...	...	...	48
Antimony	...	...	...	61
Mercury	...	...	...	76
Tin	...	...	...	100
Copper	...	...	...	137
Iron	...	...	...	125
Silver	...	...	...	106
Platina	...	...	...	182
Photometer	...	...	I.	135
Pyrometer	...	...	...	71
Pyrites	...	...	II.	117
Pyrophorus	...	...	...	201
Pulp, cerebral	...	...	...	349
Perspirable matter	...	...	...	350
Plumbago	...	...	...	117
Platina	...	...	...	—
Plants	...	...	...	331
Phial, philosophical	...	...	...	195
Pottery	...	...	...	202
Perry	...	...	I.	201
Plumula	...	...	II.	332
Prussic Acid	...	...	...	320
Prussiates	...	...	...	321
Prussiate of Potash and Iron	...	...	...	322
Lime and iron	...	...	...	324
Barytes and iron	...	...	...	—
Strontia and iron	...	...	...	—
Iron	...	...	...	—
Prussian blue	...	...	...	—
Purple precipitate of cassius	...	...	...	165
Putrefactive fermentation	...	...	...	344
Putrefaction	...	...	...	350
QUARTATION	...	...	...	175

				Vol.	Page
Quartz	...	...	...	II.	188
Quicksilver	...	...	...		72
RADICALS	...	...	...	I.	15
Radicle	...	...	...	II.	332
Rays of caloric	...	...	...	I.	101
Realger	...	...	...	II.	6
Red Lead Ore	...	...	...		20
Silver Ore	...	...	...		157
Repulsion	...	...	...		16
Rock crystal	...	...	...		188
Resin	...	...	...		336
Refrigeration	...	...	...	I.	96
Rain	...	...	...		97
SACCHOLACTIC ACID		...	...	II.	318
Saliva	...	...	...		348
Sebacic acid		...	...		326
Sebates	...	...	...		—
Salsola Salicornæa	...	...	...	II.	238
Serpentine	...	...	...		206
Sinovia	...	...	...		349
Seminal fluid	...	...	...		—
Shells	...	...	...		347
Schorl	...	...	...		26
Siderite	...	...	...		120
Silex	...	...	...		188
Silver	...	...	...		143
Ores of	...	...	...		144
Fulminating. Bertholet's	...	...	...		149
Chenevix's		...	...		150
Native	...	...	...		143
Silvering	...	...	...		153
Simple Substances	...	...	...	I.	14
Serpentine	...	...	...	II.	216
Skin	...	...	...		349

INDEX.

XXV

	Vol.	Page
Soap ...	II.	239
Soft ...	...	—
Mottled ...	...	—
Yellow ...	...	—
Ammoniacal ...	...	241
Of Lime ...	...	—
Wool ...	...	—
Barytes ...	...	—
Strontia ...	...	—
Alumine ...	...	—
Magnesia ...	...	—
Soda ...	...	237
Solids, conversion of, into the gaseous state ...	I.	91
Solidity, natural state of bodies ...	...	85
Solar phosphori ...	...	128
Substances, animal ...	II.	345
Spar, Derbyshire ...	...	246
Calcareous ...	...	—
Starch ...	...	334
Strontia ...	...	242
Stalactites ...	...	250
Stones, good conductors of heat ...	I.	80
Steatite ...	II.	216
Steel ...	...	120
Blistered ...	...	123
Cast ...	...	121
Strontia ...	...	243
Sugar ...	...	334
Sulphur ...	I.	140
Sulphuric acid ...	II.	273
Sulphates ...	...	274
Sulphate of Potash ...	...	275
Soda ...	...	—
Ammonia ...	...	—

				Vol.	Page
Sulphate of Magnesia	...	...	...	II.	275
Alumine	...	...	...		—
Lead	...	...	...		—
Zinc	...	...	...		—
Nickel	...	...	...		—
Bismuth	...	...	...		—
Cobalt	...	...	...		—
Iron	...	...	...		—
Sulphureous acid	...	...	...		276
Sulphites	...	...	...		277
Sulphite of Potash	...	...	...		—
Soda	...	...	...		—
Ammonia	...	...	...		—
Barytes	...	...	...		—
Lime	...	...	...		—
Magnesia	...	...	...		—
Lead	...	...	...		—
Bismuth		...	...		—
Antimony	...	...	...		—
Iron	...	...	...		—
Sulphureous acid gas	...	...	...	I.	317
Sulphuret of Arsenic	...	...	...	II.	10
Antimony	...		...		56
Nickel	...	...	...		39
Lead	...	...	...		112
Zinc	...	...	...		86
Tin	...	...	...		100
Mercury	...	...	...		74
Barytes	...	...	...	I.	129
Lime	...	...	...		130
Magnesia	...	...	...		152
Molybdena	...	...	...		17
Strontia	...	...	...	II.	244
Sulphurated hydrogen gas	...		...	I.	261

	Vol.	Page
TANIN	II.	337
Talc		216
Tallow		346
Tantalite		184
Tartareous acid		306
Tartrites		367
Tartrite of Ammonia		307
Potash		—
and Lime		—
Barytes		—
Strontia		—
Silver		—
Mercury		—
Lead		—
Bismuth		—
Iron		—
Copper		—
Tenacity		5
Tendons		347
Tellurium		68
Thermometers	I.	71
Theory, corpuscular		32
Tin	II.	94
Tinning of Copper		104
Iron		105
Titanium		26
Tombac		139
Tungsten		13
Turpeth mineral		77
Tungstic acid		294
Tungstates		295
Tungstate of Lime		12
Ammonia		295
Potash		—

				Vol.	Page
Tungstate of Soda	...	...	...	II.	295
Magnesia	...	...	...	—	—
VEGETATION	...	...	...		331
Vegetables	...	...	...		333
Vinegar	...	...	II. 301 and		344
Vitrous Copper Ore	...	...	...		134
Silver ore	...	...	...		144
Volatile oils	...	...	...		335
Volcano, Lemery's	...	...	...	I.	147
Vinous fermentation	...	...	...	II.	339
Verditer, blue	...	...	...		140
URANIUM	...	...	...		29
Uranitic ochre	...	...	...		—
Uric acid	...	...	...		330
Urea	...	...	...		348
Urine	...	...	...		—
Urinary calculi	...	...	...		349
WATER, production of	...	...	...	I.	204
Theory of its decomposition	...	...	...	II.	255
Decomposition of, by chemical agencies	...	...	...	—	—
Electricity and gal-					
vanism	...	...	...		257
Re-composition of	...	...	...		259
Mineral of Aix-la chappelle	...	...	...	I.	215
Harrogate	...	...	...		265
Wax	...	...	...		336
Of the ear	...	...	...		349
Whiteness, to what owing	...	...	...		197
White lac	...	...	...	II.	327
Wine	...	...	...		340
Wolfram	...	...	...		294
Ores of	...	...	...		16
Wood-tin	...	...	...		94
Wort	...	...	...		341

INDEX.

xxix

	Vol.	Page
YTTRIA	II.	215
Yttro-tantalite)		184
Ytterby		215
Yellow, patent		111
ZINC		86
Zin-grauppen		184
Zircon		208
Zostera maritima		233
Zoonic acid		330

A LIST OF CHEMICAL PREPARATIONS,

Prepared and Sold,

IN AS PURE A STATE AS POSSIBLE,

At the LABORATORY,

OF

*FREDRICK ACCUM, No. 11, Old Compton Street,
SOHO.*

ACIDS.

Arsenic	Tartareous	Mucous	Muriatic
Arsenious	Citric	Suberic	Oxi-Muriatic
Tungstic	Malic	Prussic	Phosphoric
Molybdic	Gallic	Lactic	Nitric
Acetous	Succinic	Sebacic	Nitrous
Acetic	Benzoic	Fluoric	Sulphuric
Oxalic	Camphoric	Boracic	&c. &c.

ALCALIES.

Potash, Soda, Lime, Ammonia.

EARTHS.

Silex, Alumine, Magnesia, Lime, Barytes, Strontia, Zircon,
Glucine.

METALS.

Arsenic	Molybdena	Nickel	Antimony
Zinc	Lead	Copper	Gold
Tungsten	Cobalt	Bismuth	Mercury
Tin	Iron	Silver	Platina

PHOSPHORUS.

Phosphuret of Lime, Phosphuret of Strontia, Phosphuret of Barytes...Phosphorated Ether, Phosphorated Alcohol, Phosphorated Oil.

RE-AGENTS, or TESTS.

Tincture of Cabbage, Litmus, Turmeric, Brazil-wood, Galls...
 Papers tinged with each of these Tinctures...Tincture of Cabbage, and Tincture of Litmus reddened by Acetous Acid...Barytic, Strontia, and Lime-water...Oxalate of Ammonia, Acidulous Oxalate of Potash, and Oxalate of Soda...Fluate of Soda, and Fluate of Ammonia...Carbonate of Potash, Carbonate of Soda, and Carbonate of Ammonia...Acetite and Nitrate of Lead...Muriate of Gold, Muriate of Tin, and Muriate of Mercury...Sulphate, Nitrate, and Acetite of Silver...Green and Red Sulphate of Iron...Muriate, Nitrate, and Acetite of Barytes...Triple Prussiate of Potash, Lime, and Ammonia...Tanin...Alcohol...Sulphuric and Nitric Ether...Solution of Soap, Solution of Arsenic, Solution of Gelatine...Sulphuret of Potash, Sulphuret of Lime, and Sulphuret of Magnesia...Hidro-Sulphuret of Ammonia...Glacial Acid of Phosphorus...Phosphate of Soda and Ammonia...Black, and White Flux, &c. &c.

**ALL THE DIFFERENT GASES.**

Water impregnated with Sulphurated Hydrogen Gas, with Carbonic Acid Gas, with Carbonated Hydrogen Gas, &c.

OXIGENATED MURIATE of POTASH, and Oxigenated Muriate of Lime.

FULMINATING GOLD, Fulminating Silver, and Fulminating Mercury.

CHEMICAL CHESTS,

Containing a select collection of Re-agents, for analyzing Stones, Ores, Mineral Waters, Earths, Soils, &c.

PORTABLE LABORATORIES,

Including all the preparations and apparatus necessary for the analysis of natural and artificial products.

CHESTS OF RECREATION,

Containing a Collection of Chemical Articles, for performing a variety of striking and interesting experiments.

And every other Article not in general demand, either for Philosophical, Technical, or Medicinal use.

A List of Apparatus and Instruments may be seen, vol. II. p. xxvii.







